Interactive Environments

- context and task
- theory
- interaction techniques
- **output technologies**
- input technologies

Display: Front Projection

- what we are doing here in class
- simplest way to produce visual output on any surface
- pro:
  - cheap, simple
  - even light distribution
  - no additional space needed
  - space for legs under the table

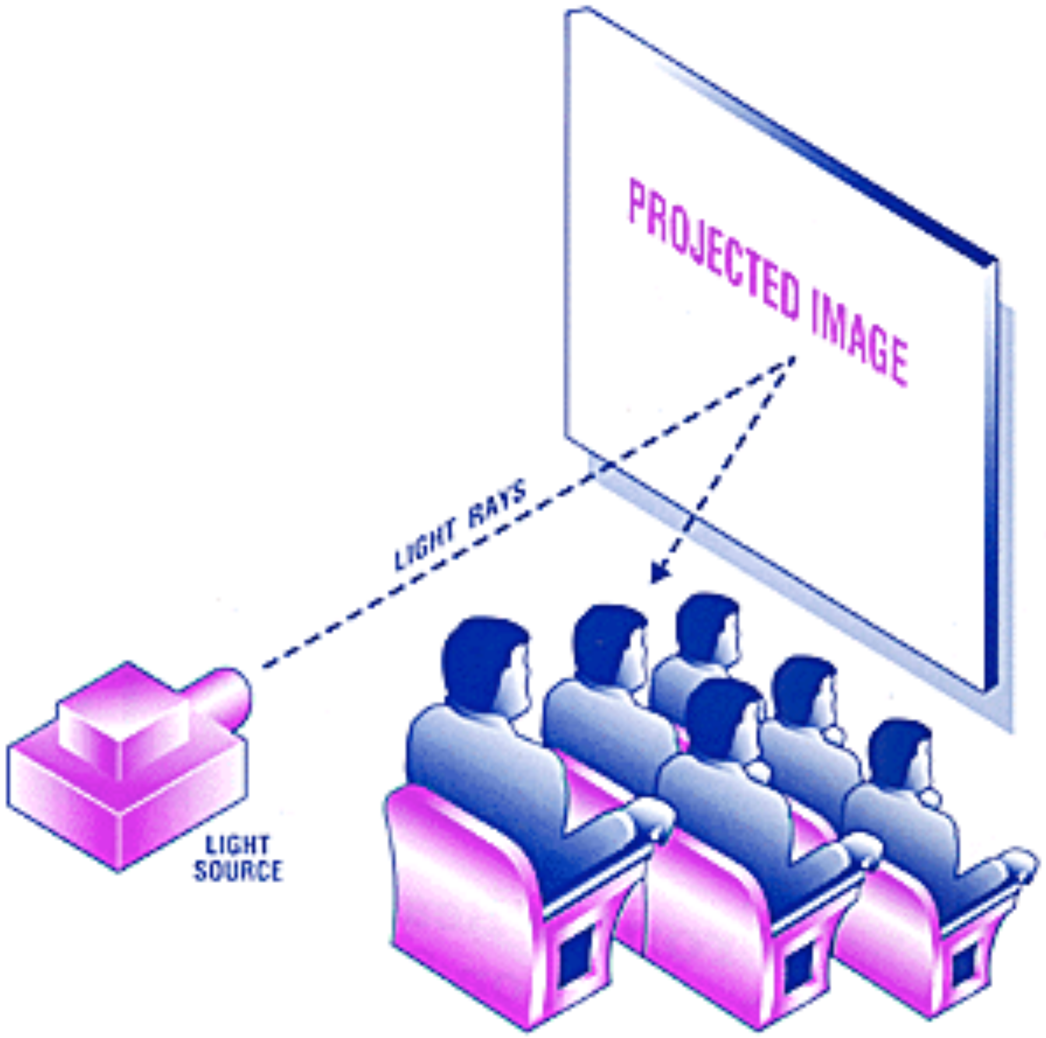


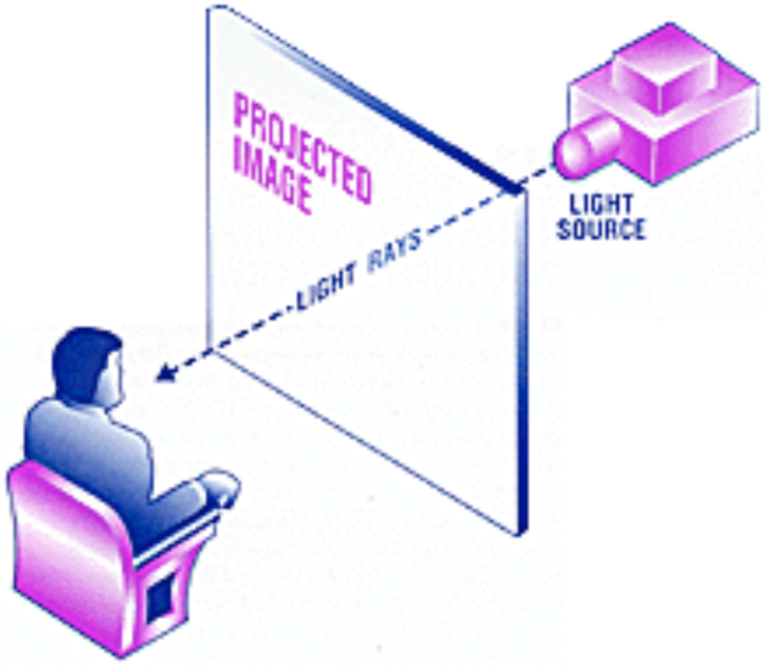
image source: http://www.rosco.com/

- contra
  - interacting hand and person cast a shadow
  - only feasible for tabletops when firmly mounted

Display: Rear Projection

- Pro:
  - projector is hidden, space in front empty
  - no shadowing of the surface

- Contra:
  - Can only be done with space behind
  - complex mirror construction for tabletops
  - can create „hot spot“ with cheap screen



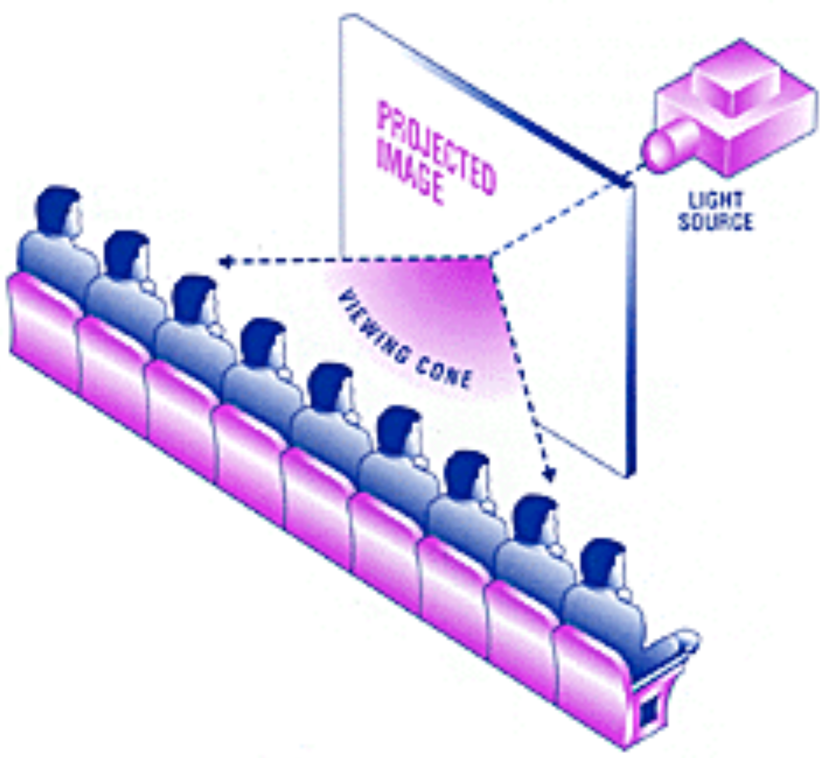
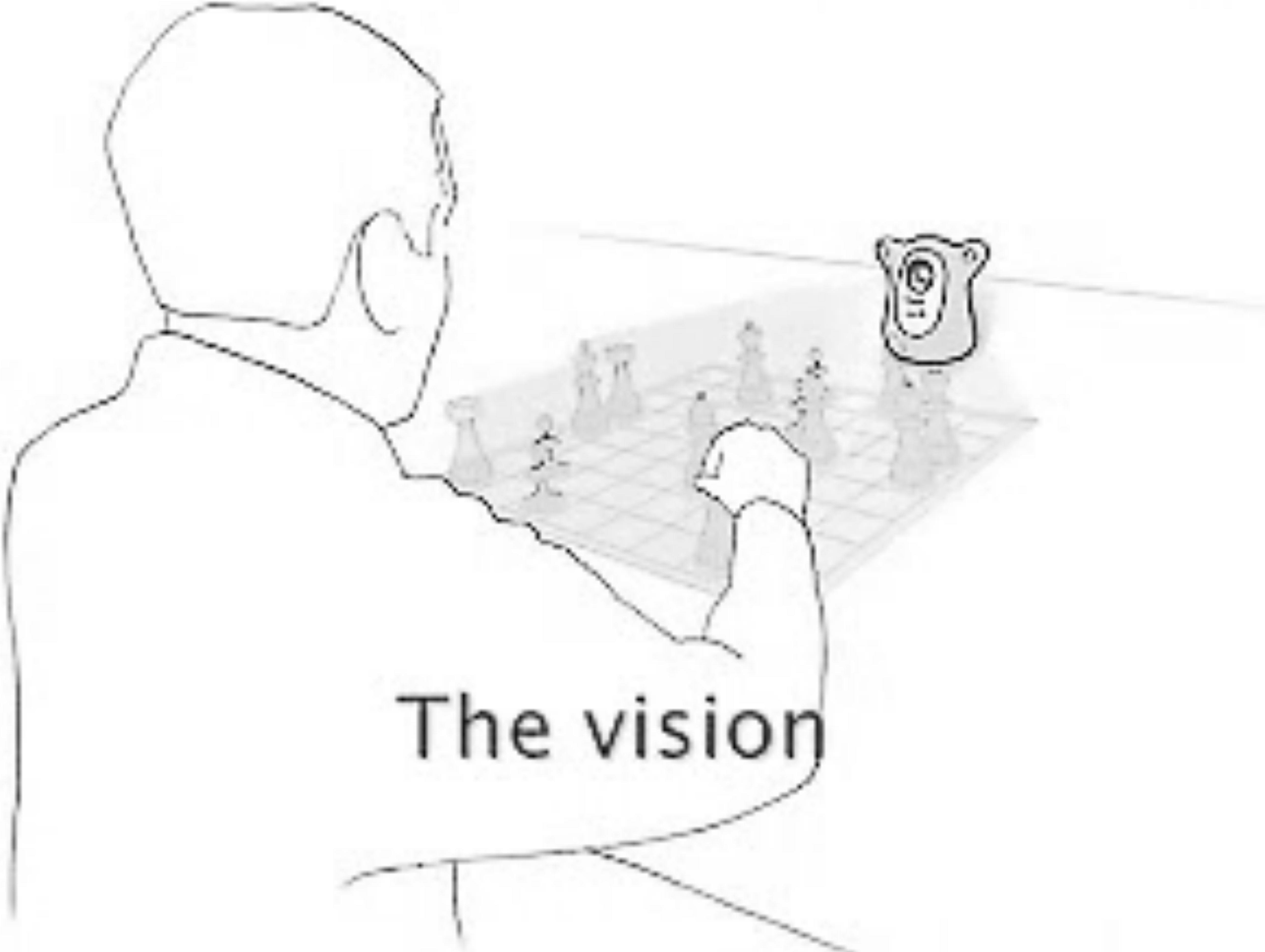


image source: http://www.rosco.com/

Display: Projection from the side ;-)

- PlayAnywhere, Andy Wilson (Microsoft Research), 2005
- Uses commercial short throw projector for front projection at an angle of 40 degrees
- Uses cameras for sensing
  - mounted off axis from the projection
  - can see shadows caused by front projection
  - can recognize fingers and markers
- Turns any flat surface (e.g., table) into an interactive surface



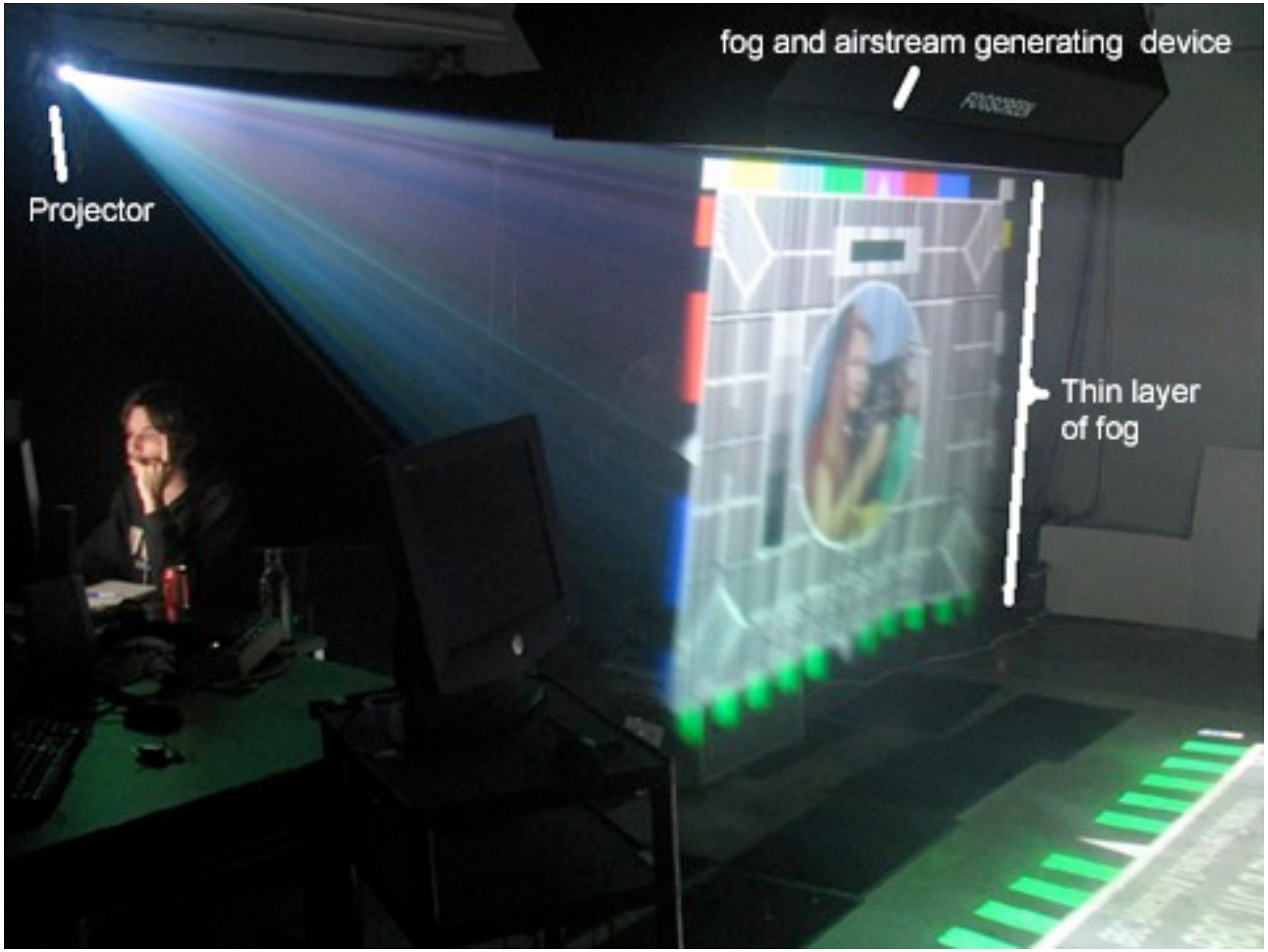
The vision

Display: Screens

- What we initially used in our tabletop research @LMU
  - High resolution and contrast + great color
  - Insensitive to ambient light
  - Can be bought with touch overlay for sensing

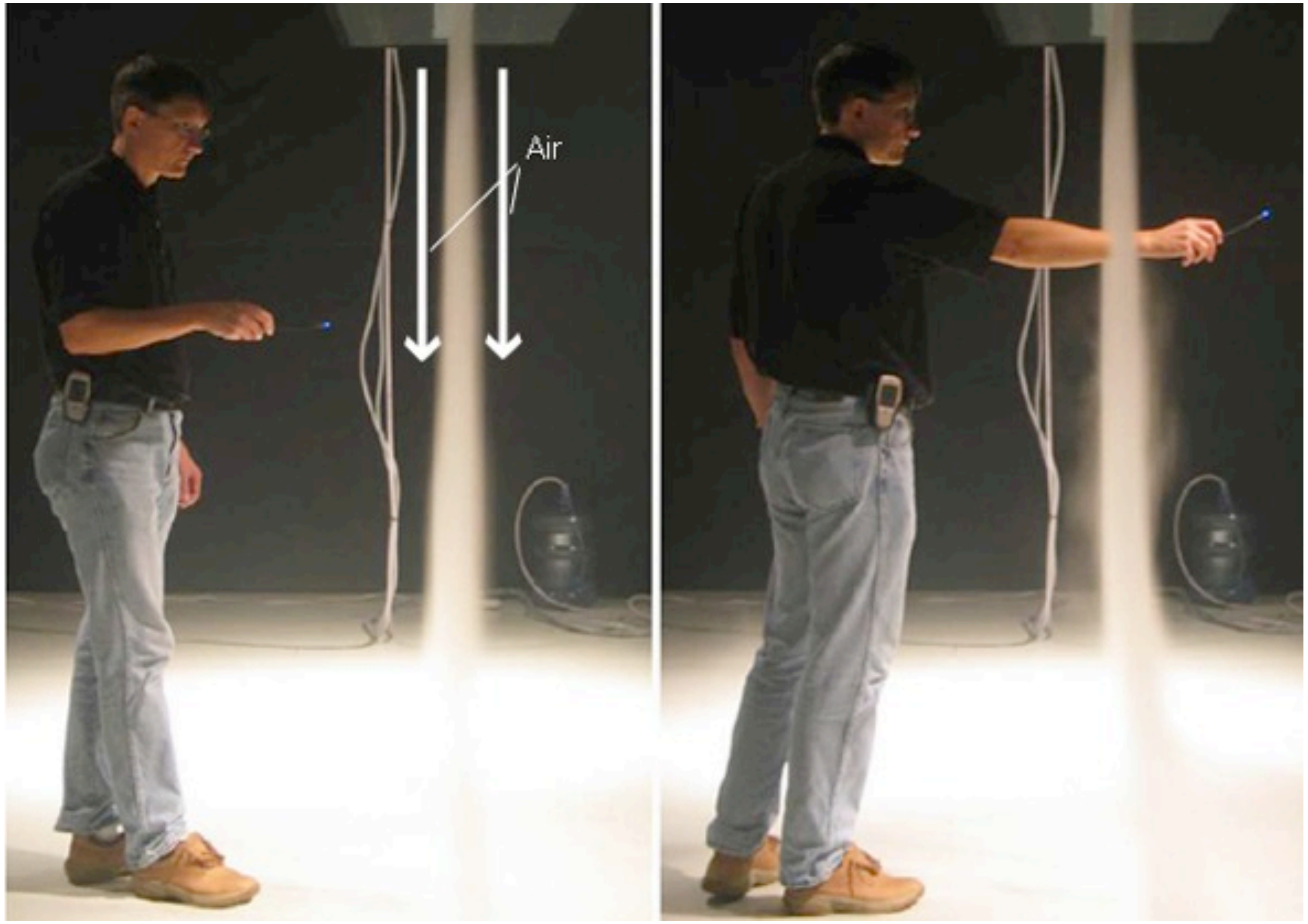
FogScreen

- A wall sized, immaterial projection display
- Image projected on dry, non-hazardous fog (pure water)
- Inventor: Ismo Rakkolainen



FogScreen (2)

- Fog sandwiched between airstreams
- Immaterial → user can reach or walk through unhindered

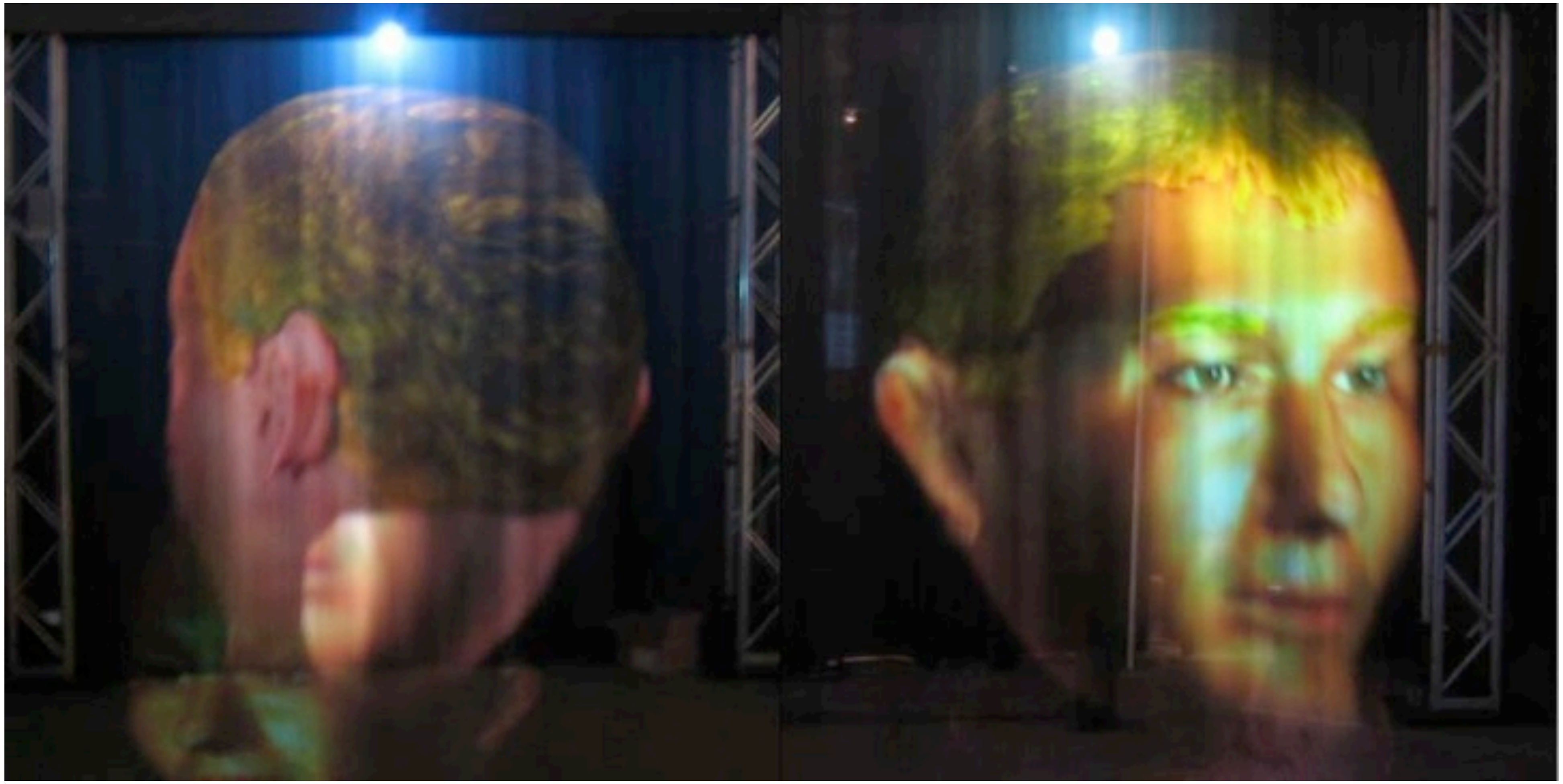


FogScreen (3)

- Technical Details
  - First introduced at UIST 2004
  - So far only 9 FogScreens in the world
  - Price: 100k $
  - Weight: around 100 kg
  - Needs: 10L/h, 300W

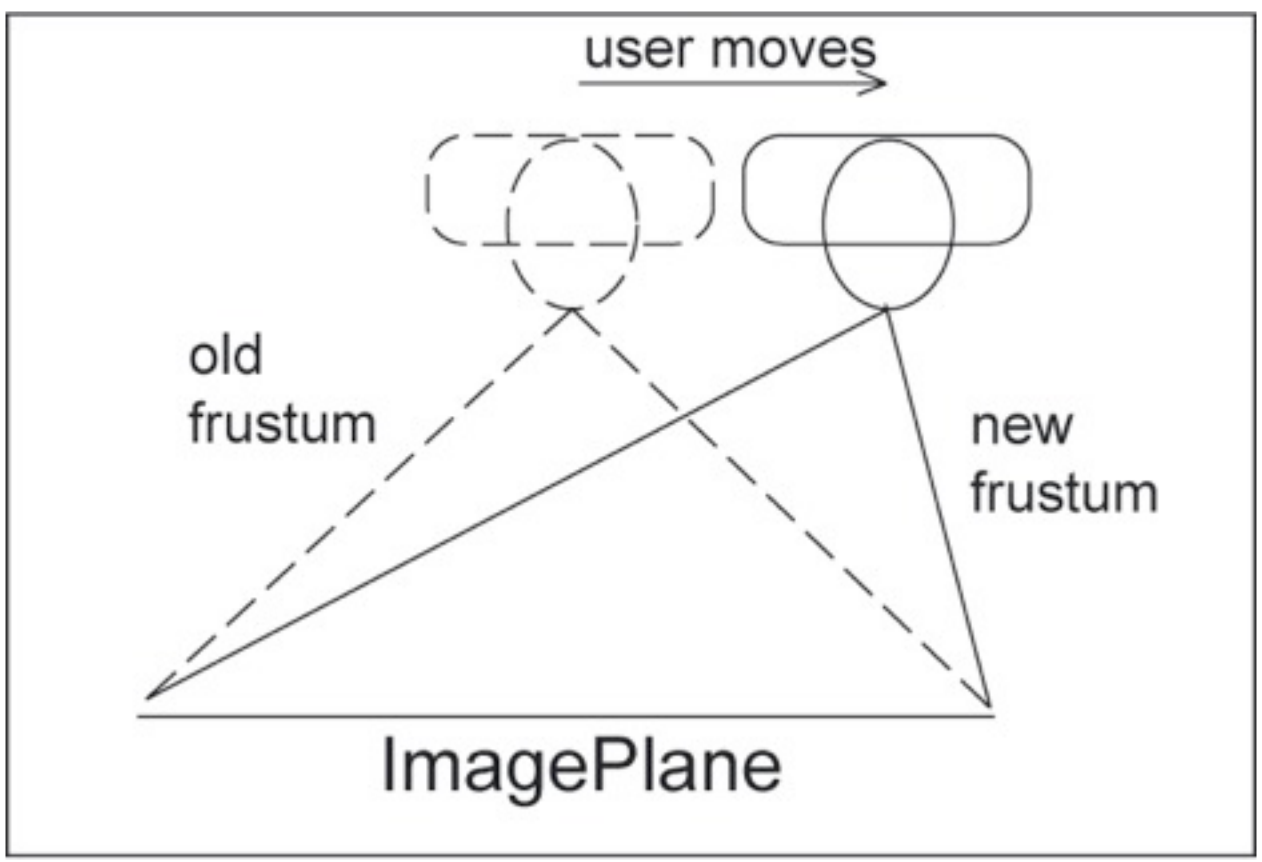
FogScreen (4)

- Pseudo 3D
  - Double sided projection possible
  - E.g. opposite views of the same scene



FogScreen(4)

- Pseudo 3D – HeadTracking (S. DiVerdi)
  - Tracking the users Head
  - Input used for adapting the frustum for accurate perspective rendering



Interactive Environments

context and task

theory

interaction techniques

output technologies

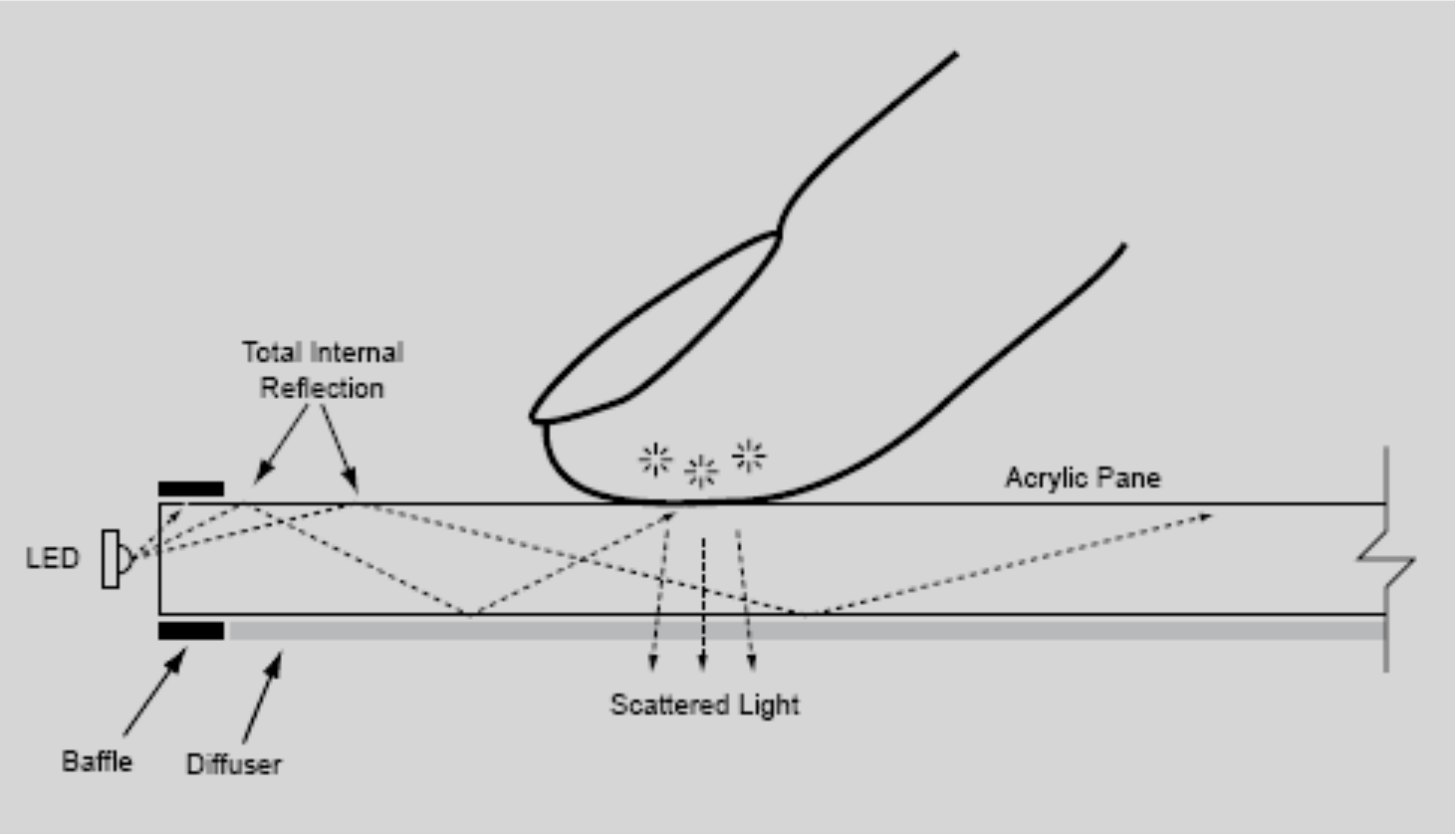
input technologies

Interactive Surfaces before the FTIR hype

- Interactive Tabletops in research since early 1990ies
  - cumbersome setups, expensive technology
  - commercial prototypes early 2000s
    - e.g., „Roomware“ 2001, photo below from Fraunhofer IPSI
  - did not really catch on at a large scale
- Interactive walls also in the 90ies
  - became commercial products as interactive whiteboards
  - front or back projection
  - sensing of one or multiple pens
  - affordable and widespread today
  - use for presentation, teaching, ...

Jeff Han and the FTIR Hype

- Jefferson Y. Han (NYU): work on a cheap multi touch sensing scheme (http://cs.nyu.edu/~jhan/ftirtouch/)
- Spin-off company „perceptive pixels“
- „FTIR Hype“ started probably with a TED talk, Feb. 2006
- many refinements and DIY projects followed



Interactive Tabletops and Surfaces Today

- Rapidly growing research field
- conference ITS
  - started in 2006 as IEEE tabletop workshop
  - 2009 in Banff, Canada: ~150 participants, 30 papers, conference status, more submissions from Germany than from USA ;-)
  - 2014 in Dresden, Germany: 179 attendees from 20 countries, 31papers + 23 posters + 14 demos, 27% acceptance rate
- Commercial interest since „Perceptive Pixels“ and the Microsoft Surface
- Multi Touch also popularized by the iPhone / iPad etc...

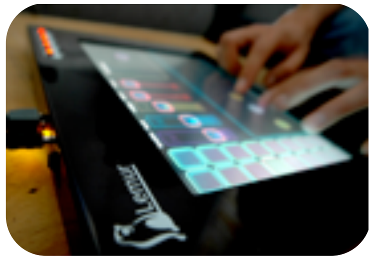
SUN Starfire - an early vision

- concept video produced in 1992
- only shows existing or almost existing technology
- features a curved high resolution interactive surface
- multimodal interaction with the system
- http://www.asktog.com/starfire/

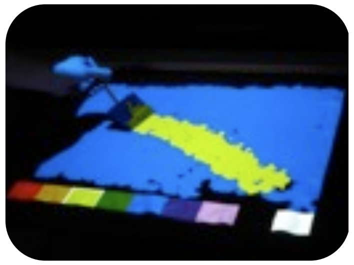
Sensing

- Embedded sensors
  - Capacitive
  - Resistive
  - Optical
- Camera Infrared
  - FTIR
  - Diffuse Illumination
- Others



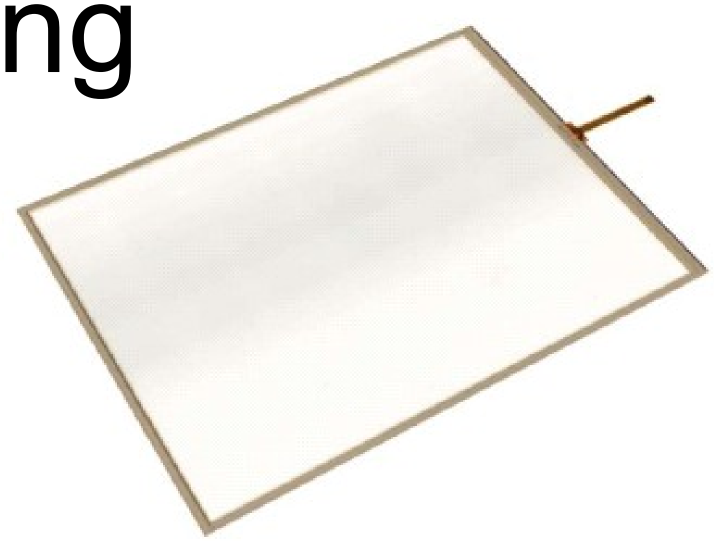




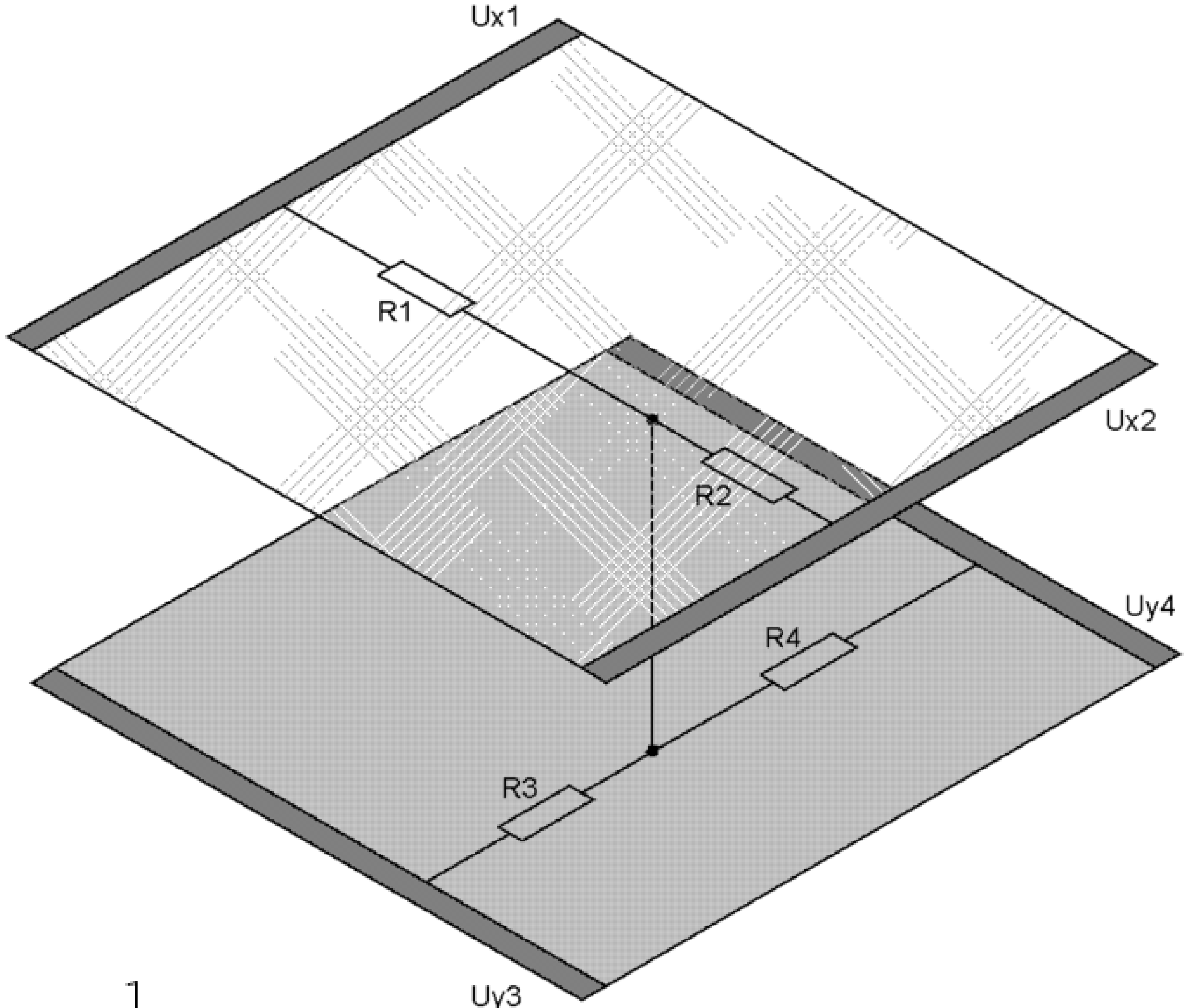



Classical (resistive) Touch Sensing

[http://de.wikipedia.org/wiki/Touchscreen]



- Two sheets of conductive, transparent material
- Connected by finger or pen pressure
- Resistance measurements
  - Between X electrodes
  - Between Y electrodes



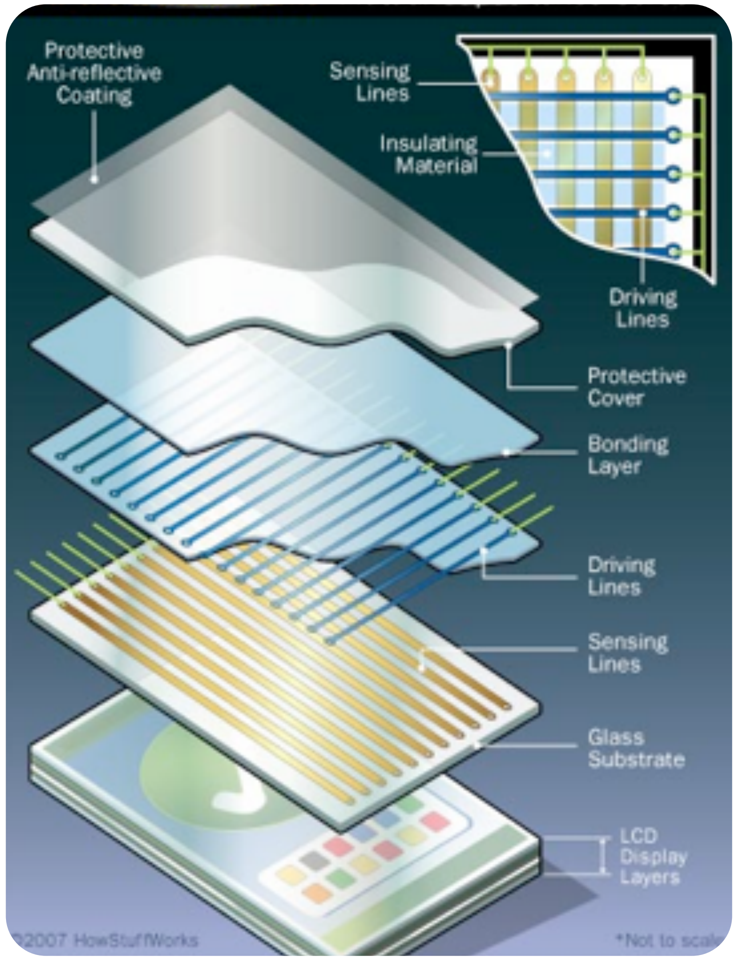
$$Uy_3 = Uy_4 = Ux_2 + \frac{(Ux_1 - Ux_2) * R_2}{R_1 + R_2} = 0V + 5V * \frac{1}{3} = 1,66V$$

Capacitive Touch Sensing

- Layer of conductive material holds charge
- Finger approaching the surface changes the amount of charge
- requires grid of driving and sensing lanes
- OR individual electrodes embedded in one layer

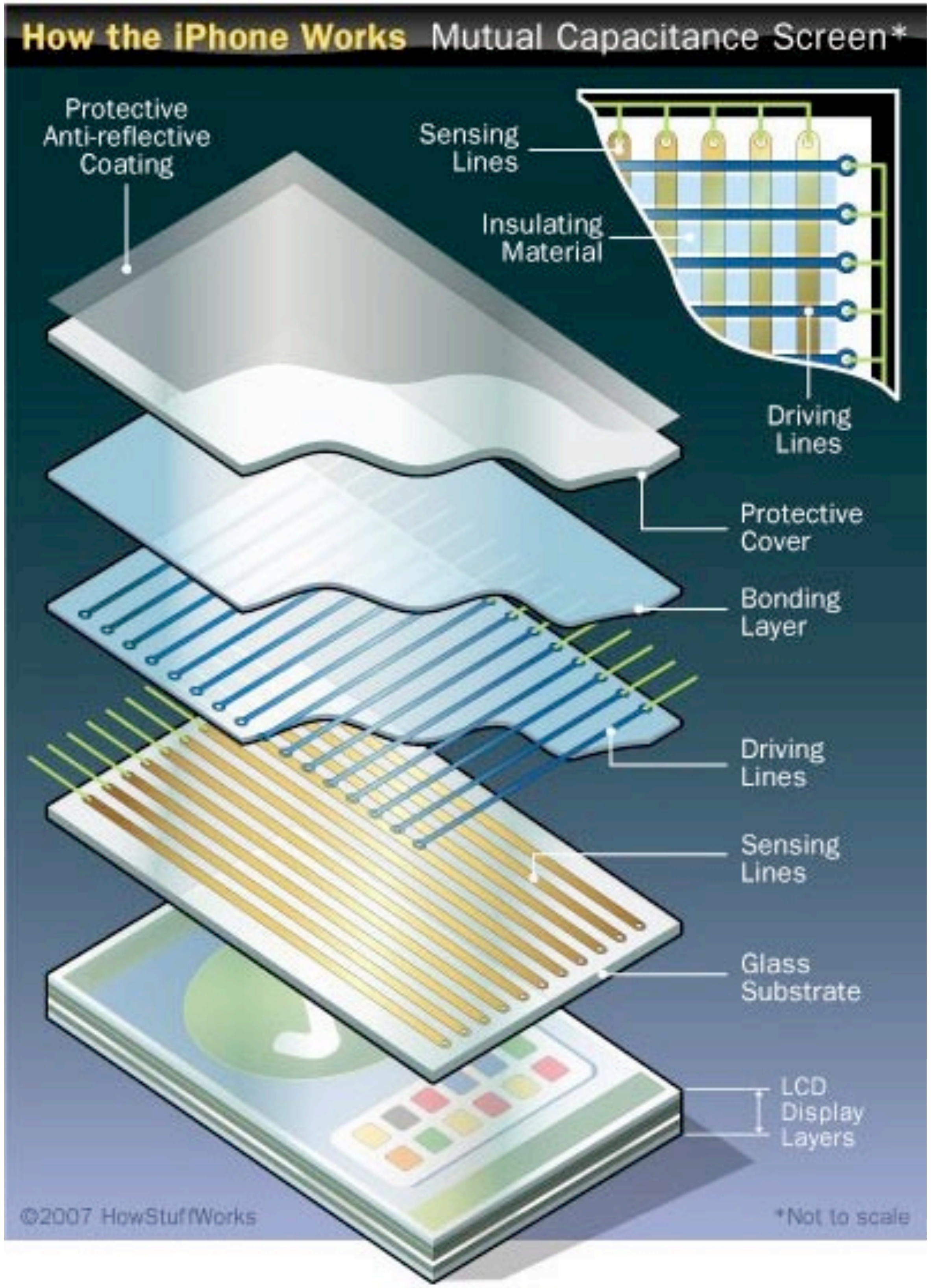

[Dietz Leigh'01]

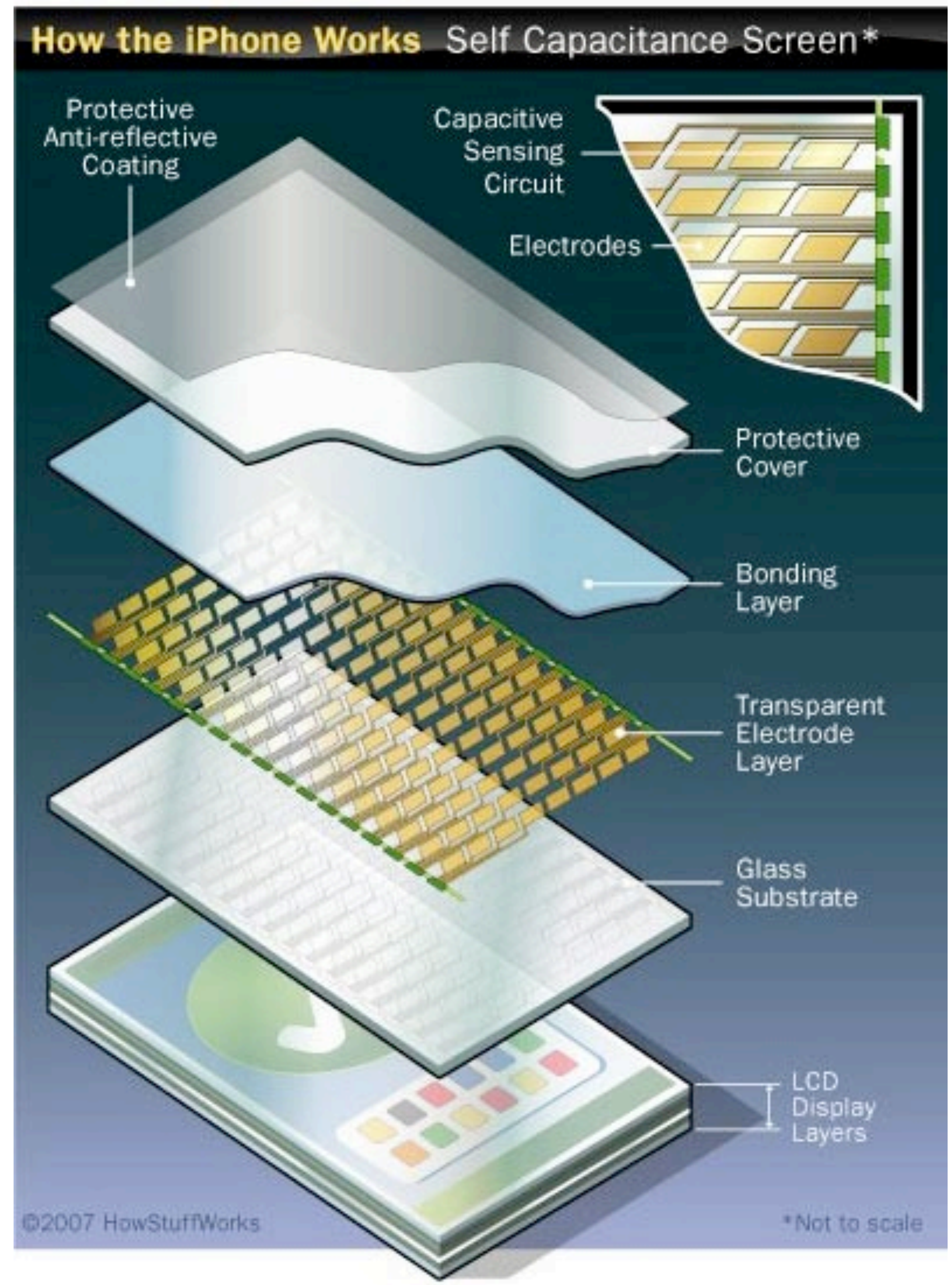

[Rekimoto'02]



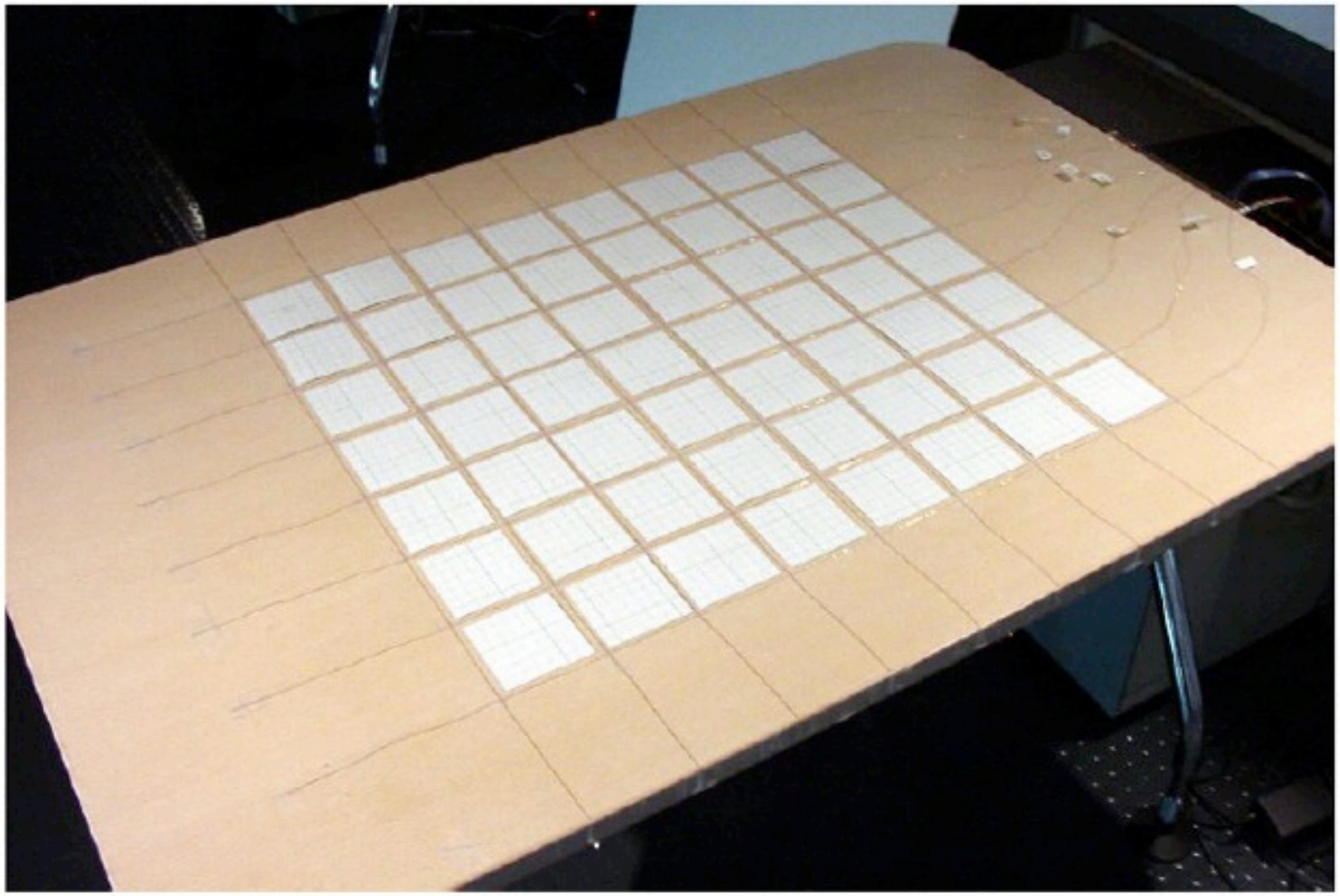
Projected Capacitive Touch: iPad + iPhone

http://electronics.howstuffworks.com/iphone2.htm





Capacitive Sensing: Sony SmartSkin



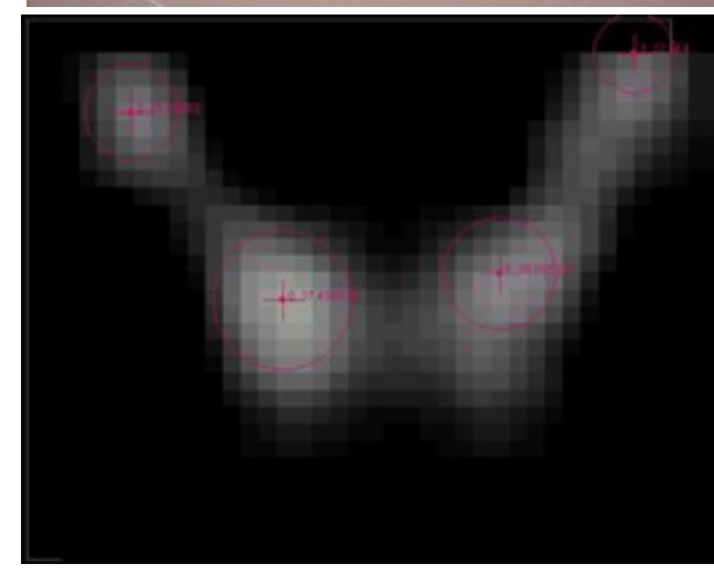


Figure 3: Interactive table with an 8 × 9 SmartSkin sensor: A sheet of plywood covers the antennas. The white squares are spacers to protect the wires from the weight of the plywood cover.

Capacitive Sensing: Sony SmartSkin

- finger only changes capacitive coupling in grid

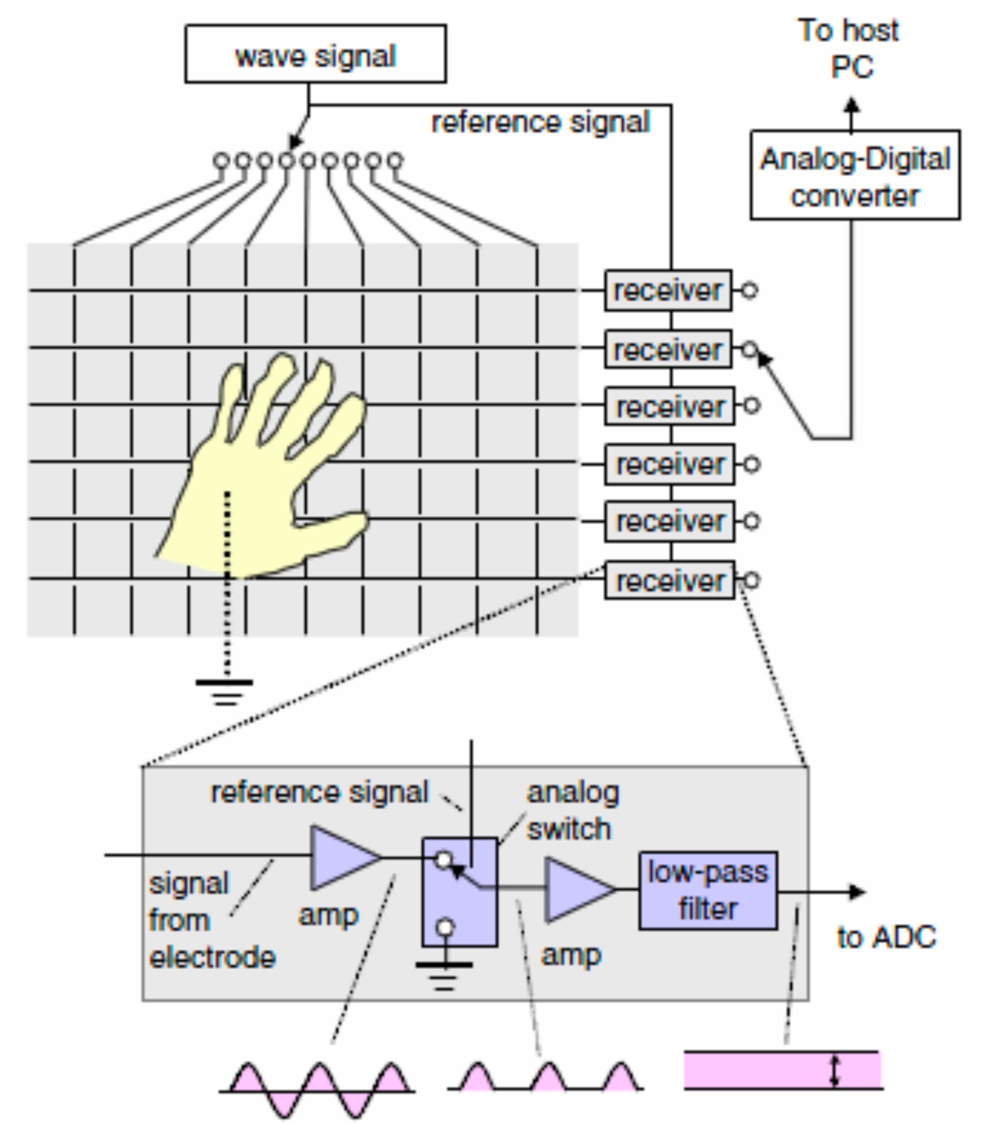


Figure 2: The SmartSkin sensor configuration: A mesh-shaped sensor grid is used to determine the hand's position and shape.

Capacitive Sensing: MERL DiamondTouch

Dietz, P.; Leigh, D. "DiamondTouch: A Multi-User Touch Technology". UIST 2001

- finger acts as one electrode of the capacitor
- connection e.g., through the chair
- different users send different signals
- finger identification solved!!

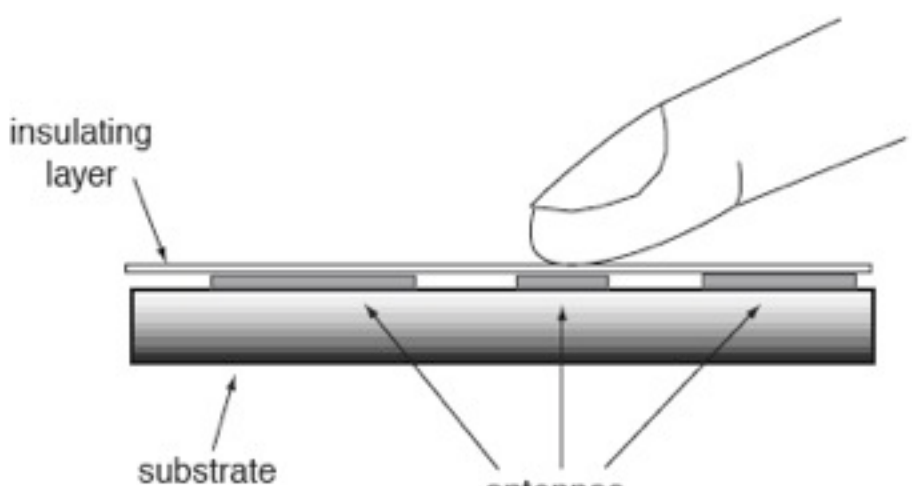
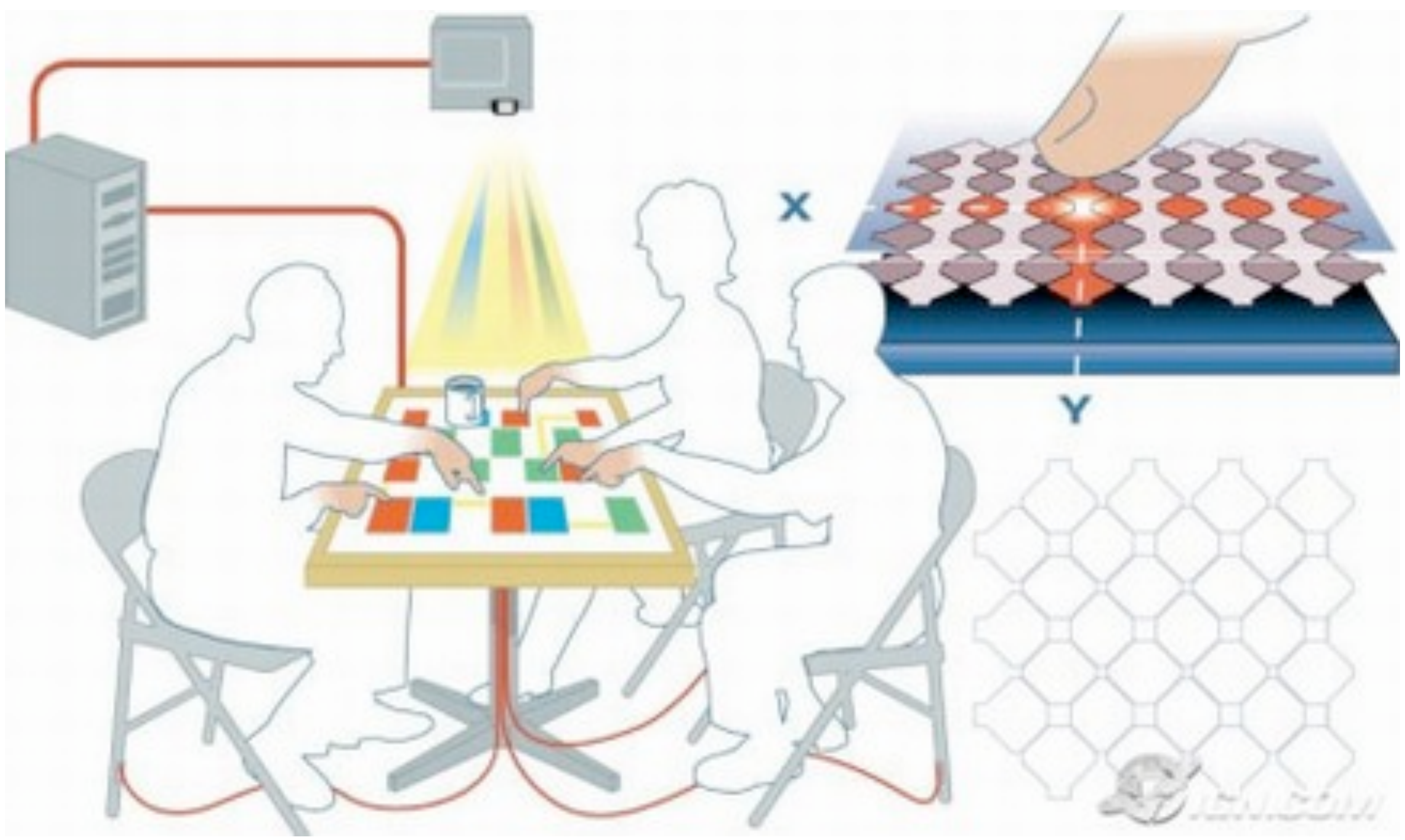
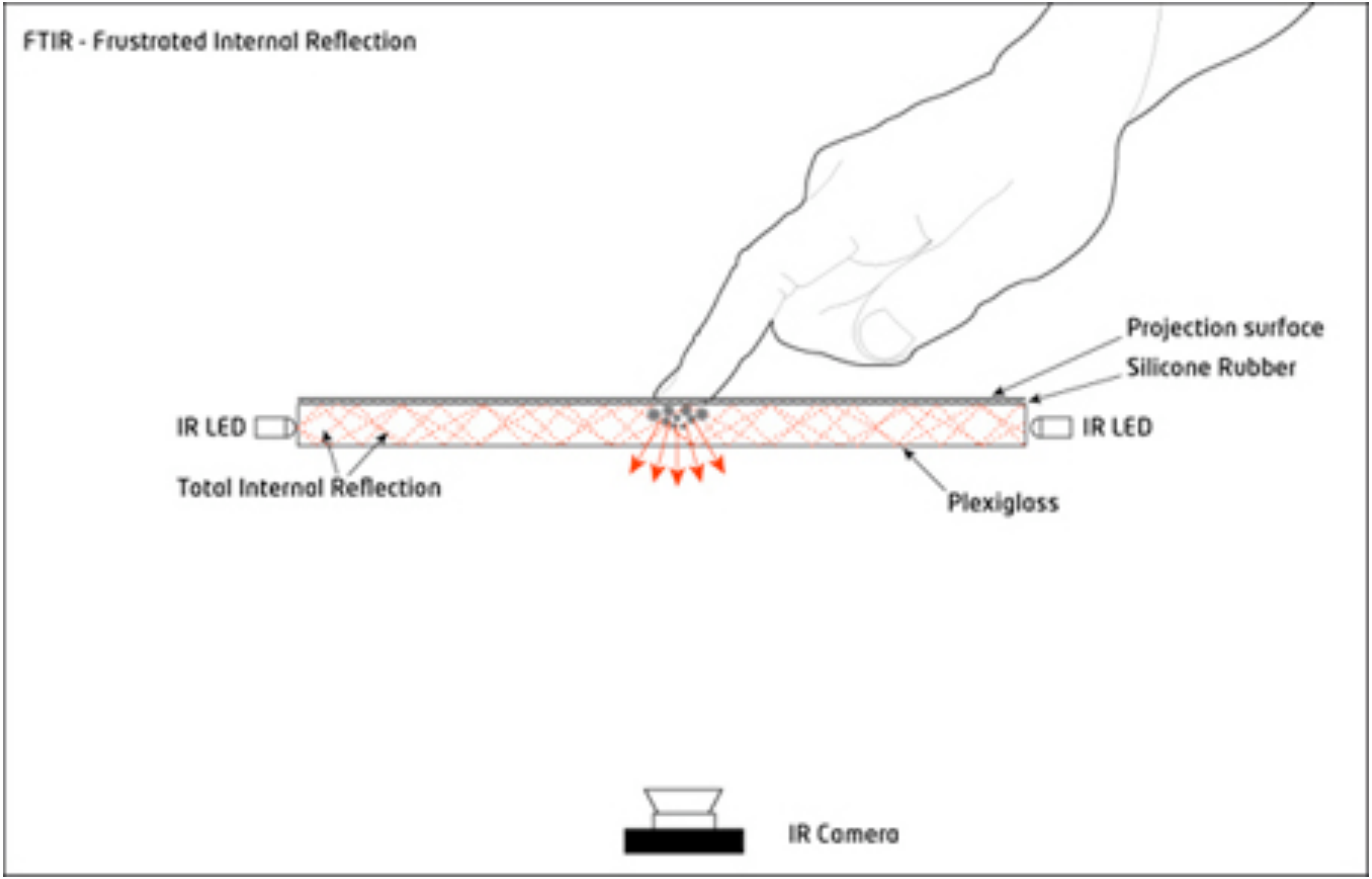


Figure 3: A set of antennas is embedded in the table-top. The antennas are insulated from each other and from the users.

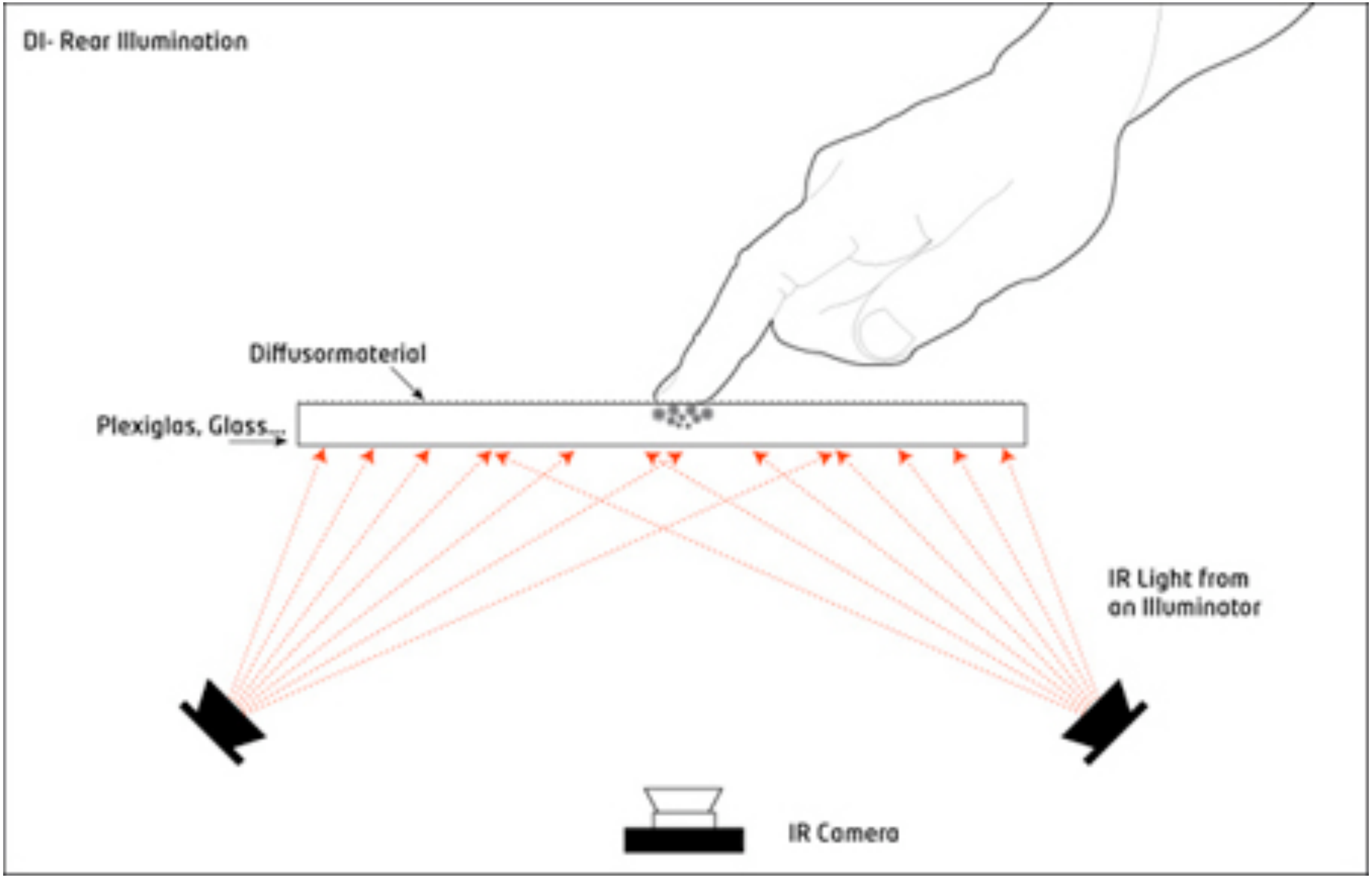


Optical Sensing - FTIR



http://iad.projects.zhdk.ch/multitouch/

Optical Sensing - DI



http://iad.projects.zhdk.ch/multitouch/

TouchLight

http://www.youtube.com/watch?v=96QvGj_SLwk

- Andy Wilson, ICMI 2004
- Projection onto Holofilm (transparent projection screen)
- imaging through the screen ==> funny effects possible

Optical tracking from the side: SmartTech SmartBoard DViT


Figure 1: DViT Technology Camera

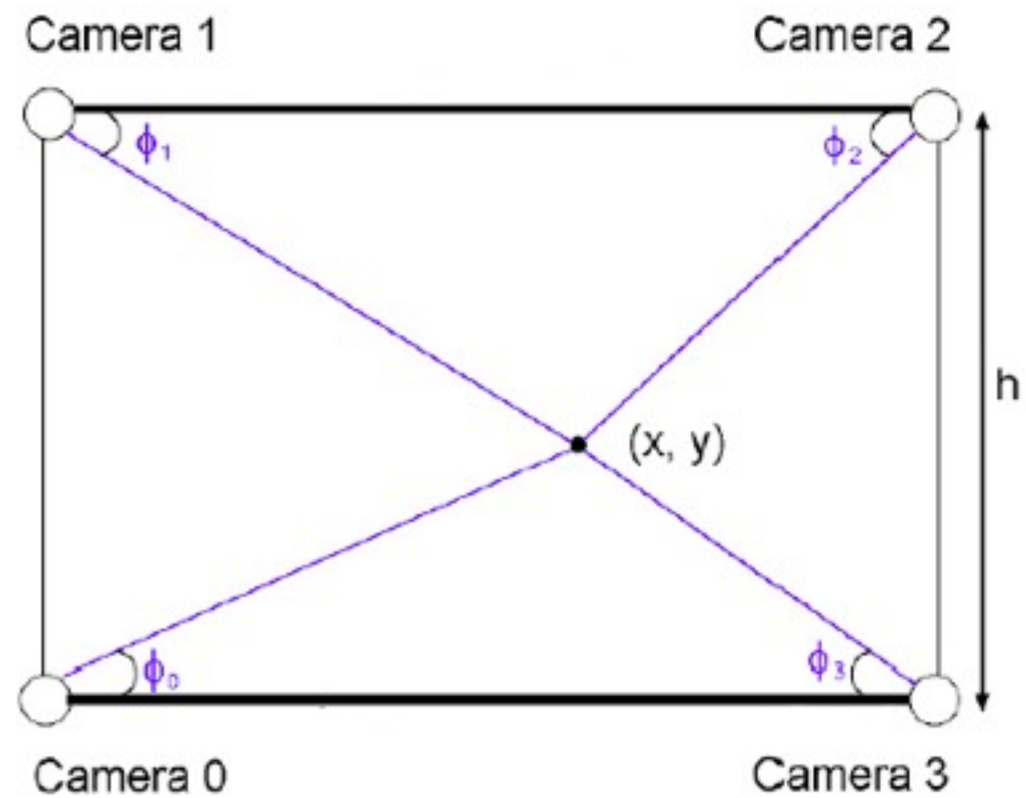
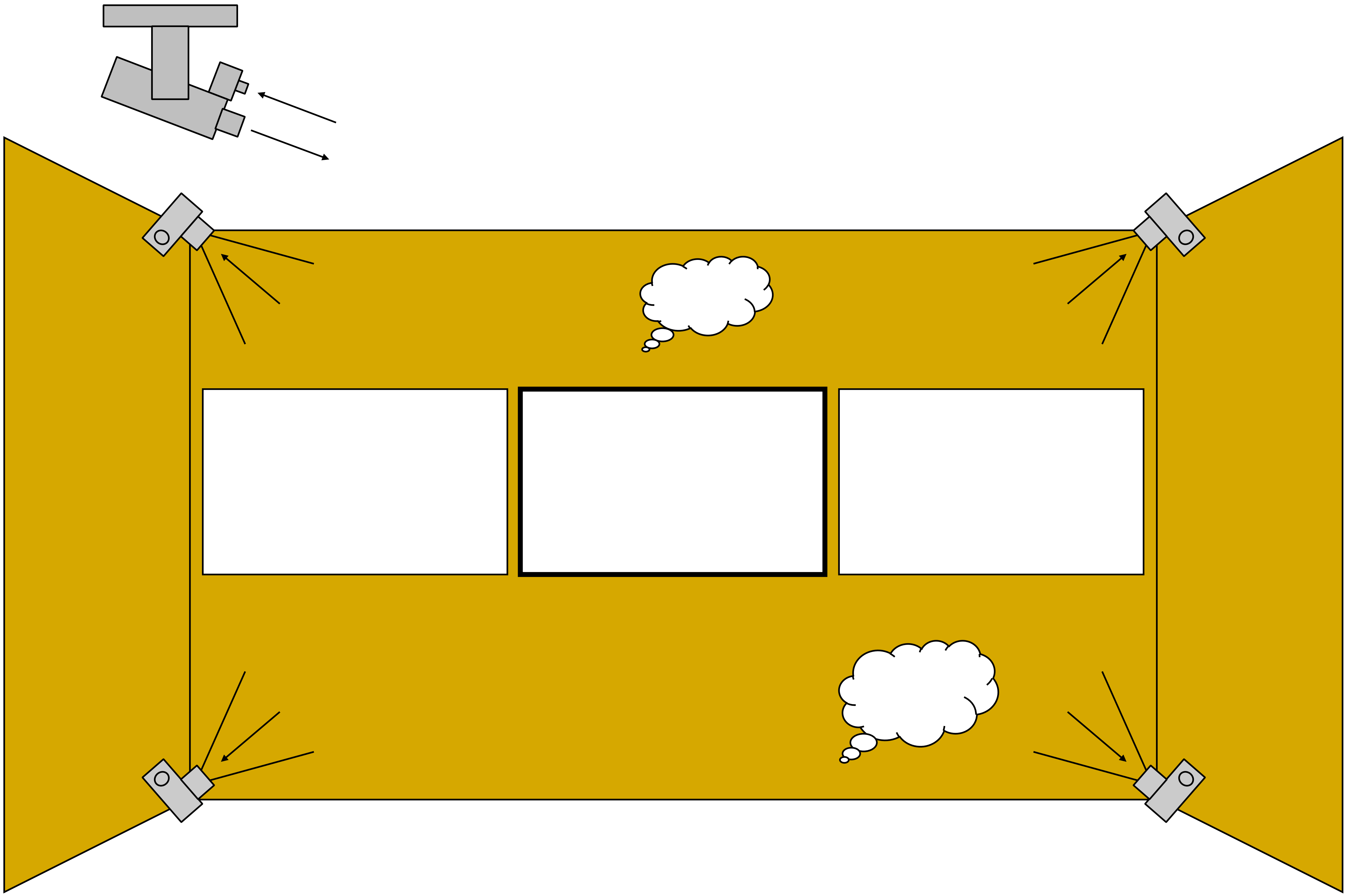


Figure 2: Camera Identification of a Contact Point

- 4 cameras, 100FPS
- can be overlaid to screens, projection surfaces etc..
- theoretically 4, practically 2 (narrow) contact points
- http://www.smarttech.com/dvit/index.asp

A Wall-sized Focus+Context Display
[Boring, Hilliges, Butz, PerCom 2007]



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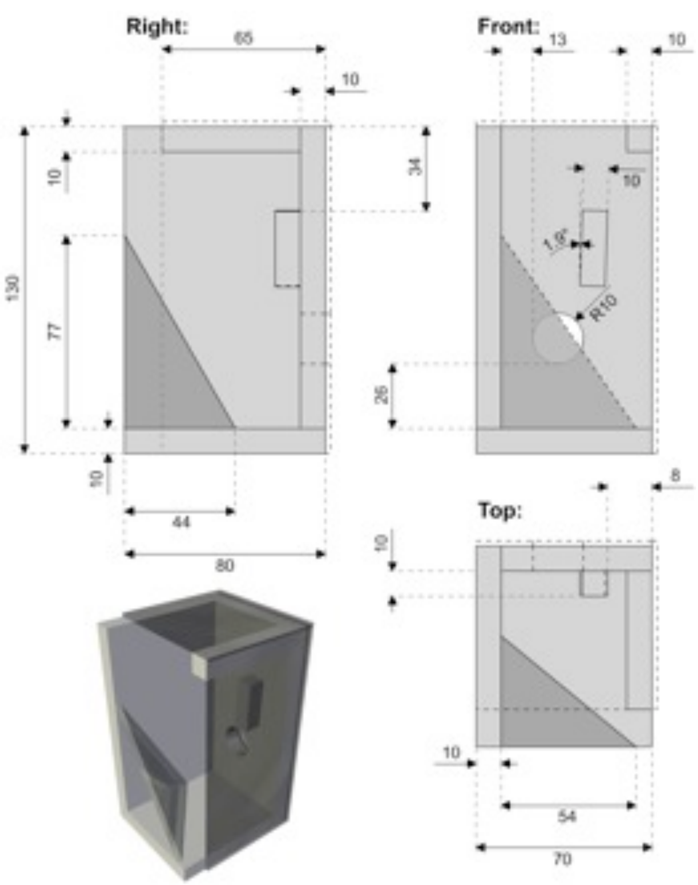
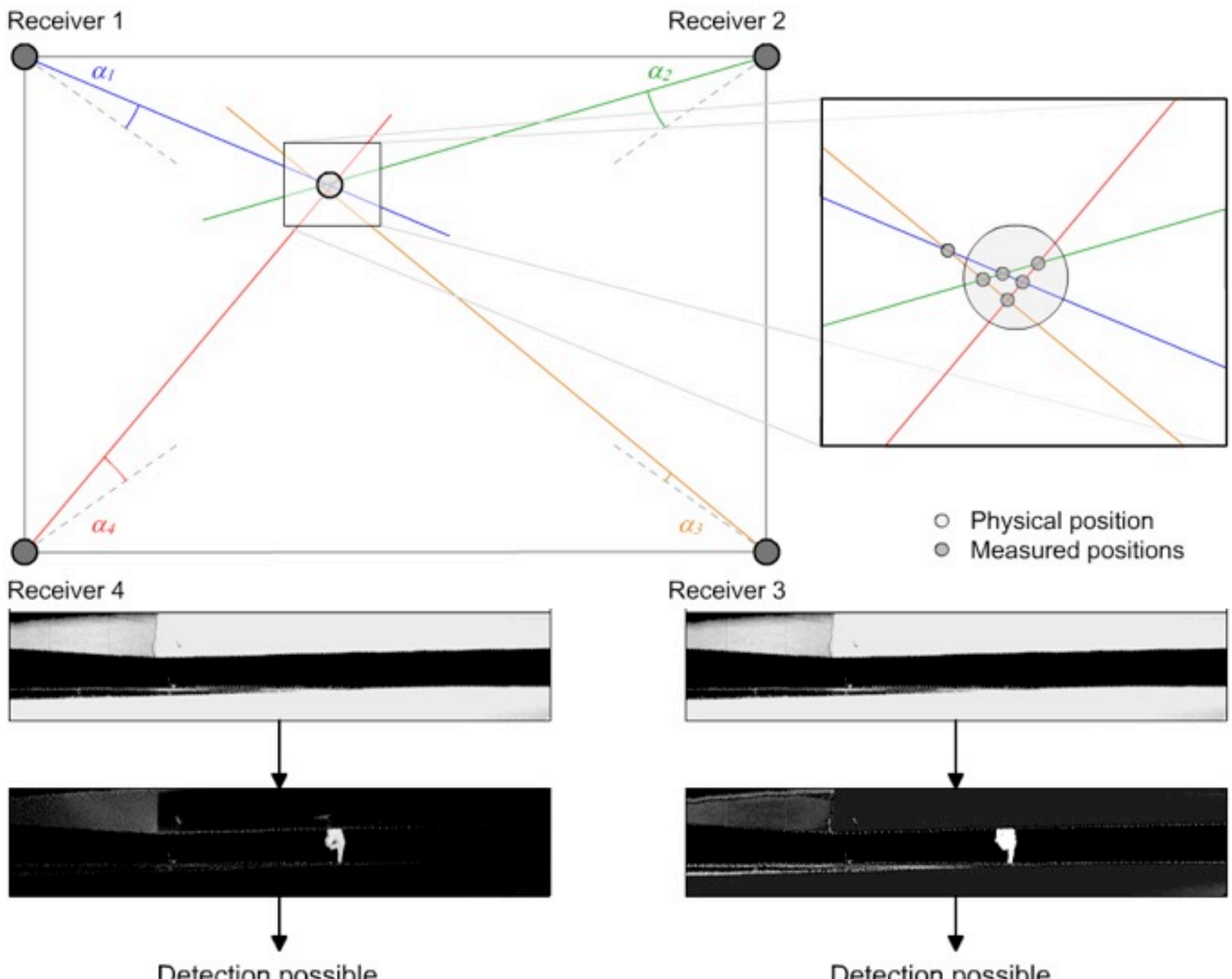
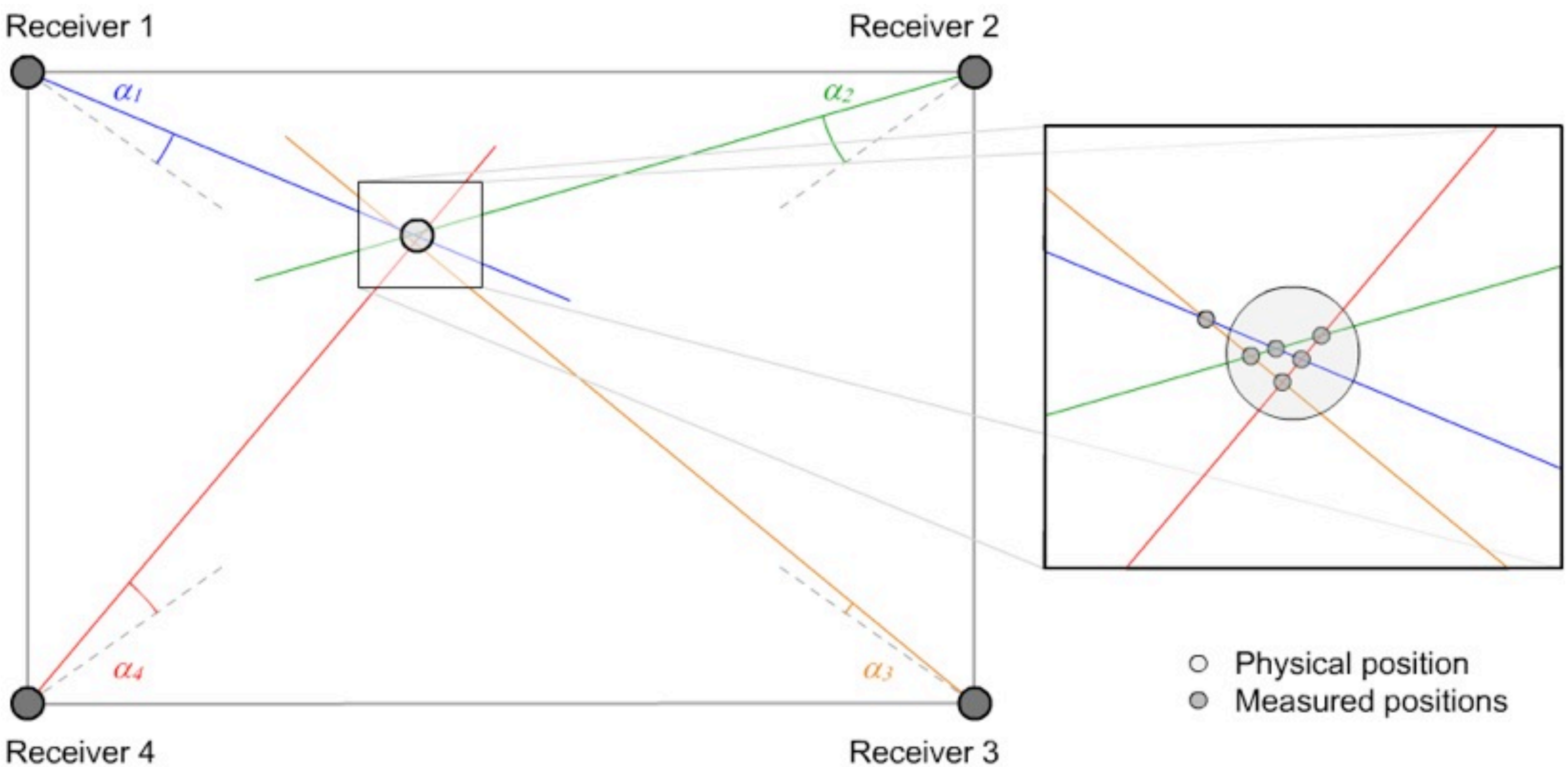




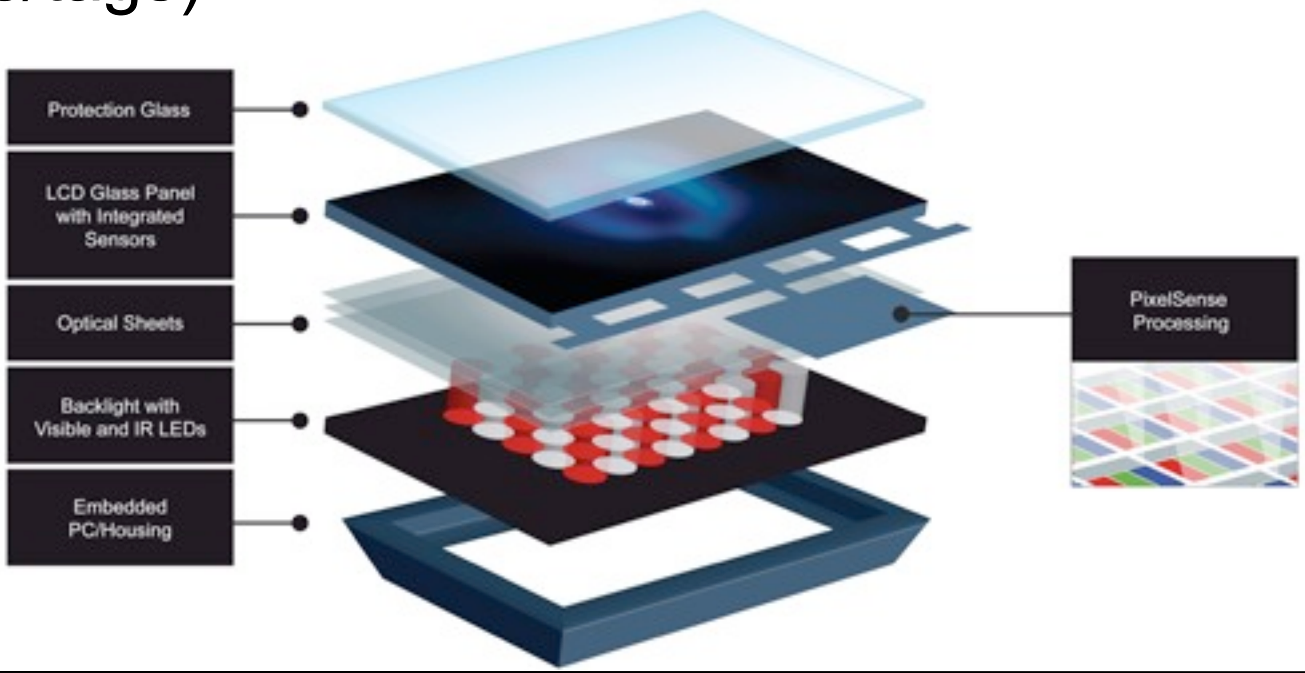
Brief discussion for understanding

- How many fingers can be detected? Why?
- How can this be formalized mathematically?
- How can we keep finger IDs over time?
- What are the critical cases?

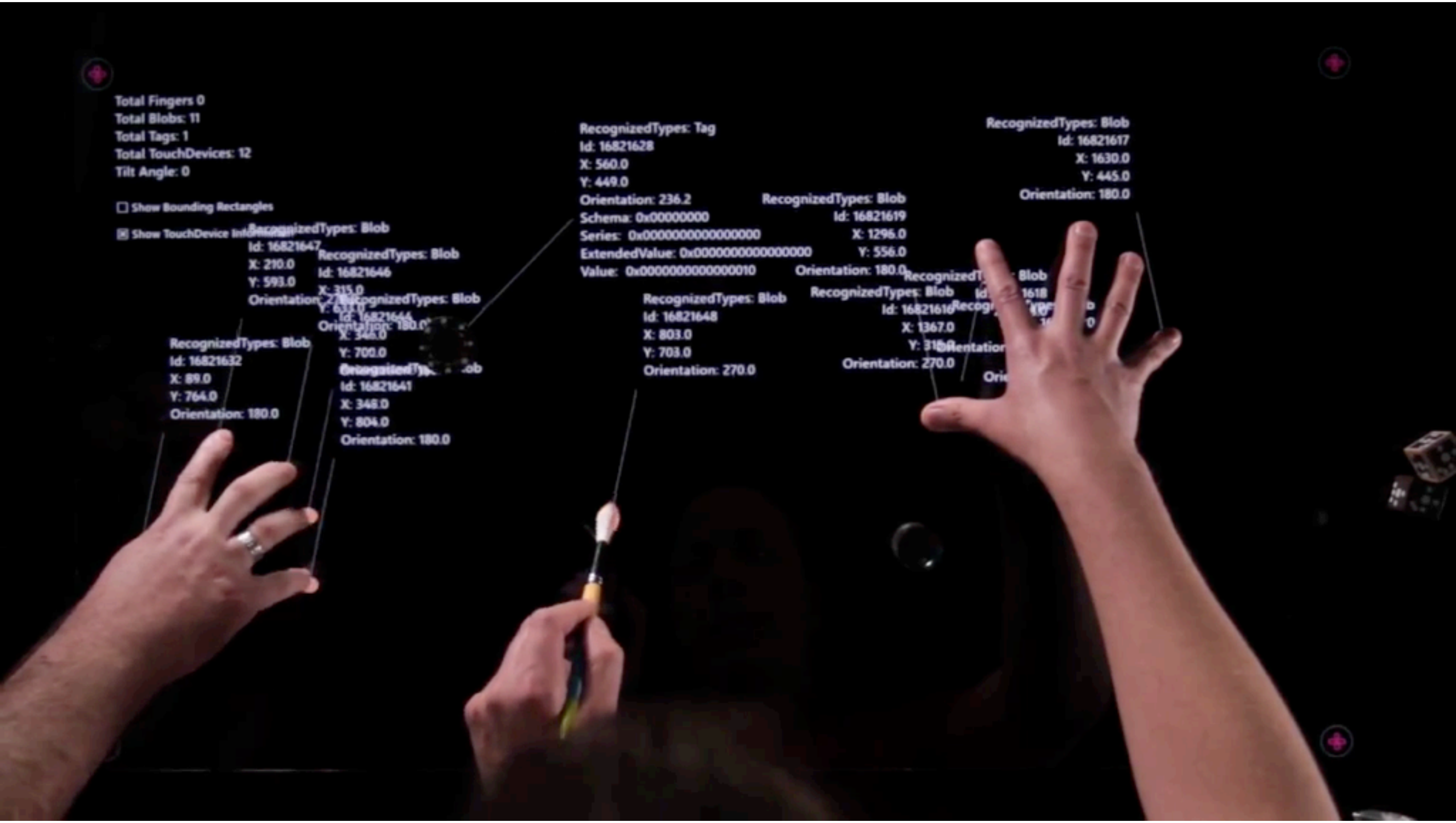


Microsoft PixelSense (2011)

- A contact (finger/blob/tag/object) is placed on the display
- IR back light unit provides light (though the optical sheets, LCD and protection glass) that hits the contact.
- Light reflected back from the contact is seen by the integrated sensors
- Sensors convert the light signal into an electrical signal/value
- Values reported from all of the sensors are used to create a picture of what is on the display
- The picture is analyzed using image processing techniques
- The output is sent to the PC. It includes the corrected sensor image and various contact types (fingers/blobs/tags)
- source: http://www.microsoft.com/en-us/pixelsense/
- http://www.samsunglfd.com/solution/sur40.do



Microsoft PixelSense



Commercial and semi-OTS Interactive tables

- MS surface 2 http://www.microsoft.com/en-us/pixelsense/
- Interactable http://www.ipsi.fraunhofer.de/ambiente/english/projekte/projekte/ineractable.html
- SmartTable http://www2.smarttech.com/st/en-US/Products/SMART+Table/
- Reactable http://www.reactable.com/
- Lemur http://www.jazzmutant.com/

Microsoft Surface 1

PHYSICAL DIMENSIONS

Surface unit including display and housing (L x W x H)

42.5 x 27 x 21 inches/108 x 69 x 54 cm

With metal panels: 180 pounds/82 kg
Available in U.S. and Canada only

With acrylic panels: 198 pounds/90 kg

Shipping pallet and container (L x W x H)

49 x 34 x 32.5 inches/124.5 x 86 x 82.5 cm

Pallet, box, foam: 80 pounds/36 kg

TECHNICAL SPECIFICATIONS

Display

- Type: 30-inch XGA DLP® projector
- ATI X1650 graphics card with 256 MB of memory
- Maximum resolution: 1024 x 768
- Lamp mean-life expectancy: 6,000+ hours
- Maximum pressure on the display: 50 pounds per square inch/3.5 kg per cm
- Maximum load: 200 pounds

Input Devices

- Camera-based vision system with LED infrared direct illumination

Computing System

- 2.13-GHz Intel® Core™ 2 Duo processor
- Memory: 2 GB dual-channel DDR2
- Storage: Minimum 250 GB SATA hard-disk drive

Network Protocols and Standards

- Network adapter: Intel Gb LAN
- Wireless LAN connectivity supported: Yes
- Networking and Data Protocols: IEEE802.11b, IEEE802.11g, Bluetooth 2.0, Gigabit Ethernet

I/O Connections

- 2 headphone jacks
- 6 USB 2.0 ports
- RGB component video
- S-VGA video (DB15 external VGA connector)
- Component audio
- Ethernet port (Gigabit Ethernet card [10/100/1000])
- External monitor port
- Bays for routing cables
- On/Standby power button

Microsoft Surface 2 = Samsung SUR40

http://www.samsunglfd.com/solution/feature.do?modelCd=Surface

PixelSense™

PixelSense™ allows an LCD display to recognize fingers, hands, and objects placed on the screen, including more than 50 simultaneous touch points. With PixelSense™, pixels in the display see what's touching the screen and that information is immediately processed and interpreted.

Samsung SUR40 with Microsoft® PixelSense™

Samsung SUR40 provides business customers a premier touch-first experience for their end-users, built on the principles of direct interaction and together computing, with a new look and feel. It also allows commercial application developers to use a new version of the Microsoft® Surface® SDK and familiar Microsoft development tools to take full advantage of the massive multi-touch and object recognition capabilities of PixelSense™ and deliver experiences not possible on any other platform.

40-Inch High-Definition Screen

The 40-inch high-definition screen enables unparalleled multi-touch, multi-user experience with a 1080p, 16:9, 1920 x 1080 display.

Thin Form Factor with Multiple Configuration Options

The product is four inches thin, which makes it easy to use in a horizontal deployment, hang on the wall with the VESA mount, or embed in walls or custom enclosures. There are standard legs available or a customer can design and attach their own.

Powerful Embedded System

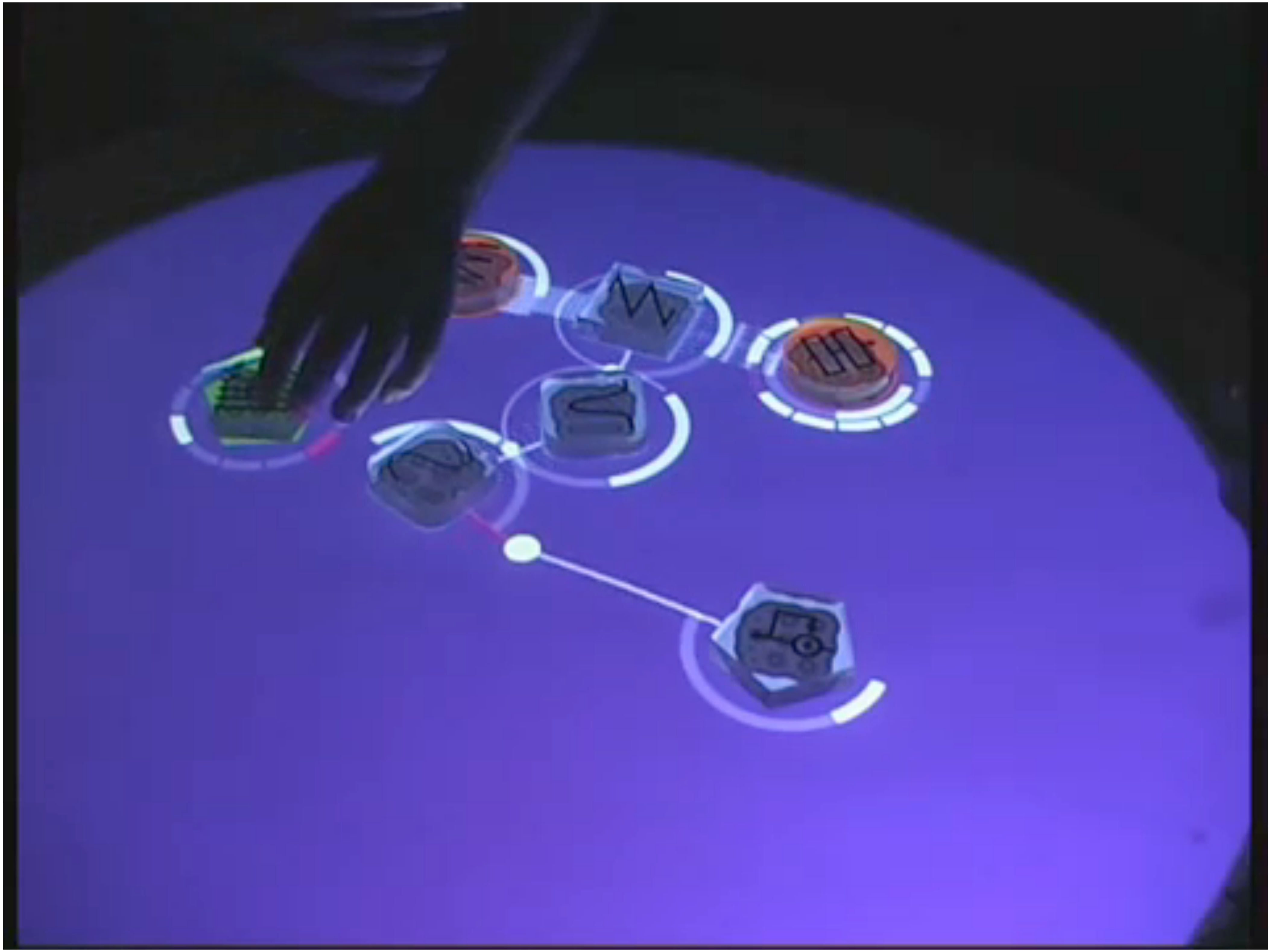
The product uses the embedded AMD Athlon™ II X2 Dual-Core Processor 2.9GHz paired with AMD HD6750M GPU featuring DirectX® 11 support to deliver significant processing horsepower and outstanding graphics capability.

FhG Interactable

- The new InteracTable® is 90 cm high with a display size of 70 cm x 125 cm. The horizontal workspace is realized with a touch-sensitive plasma-display (PDP) which is integrated into the table top of the InteracTable.
- People can use pens and fingers for gesture-based interaction with information objects. The IT components are mounted below. The margin of the table surface can be used to lean on it and to place additional material or coffee cups and the like.
- SmartTech DViT sensing: dual touch
- http://www.wilkhahn.com/loadframes.html?/2_produkte/2142.htm

SMART Technologies SmartTable

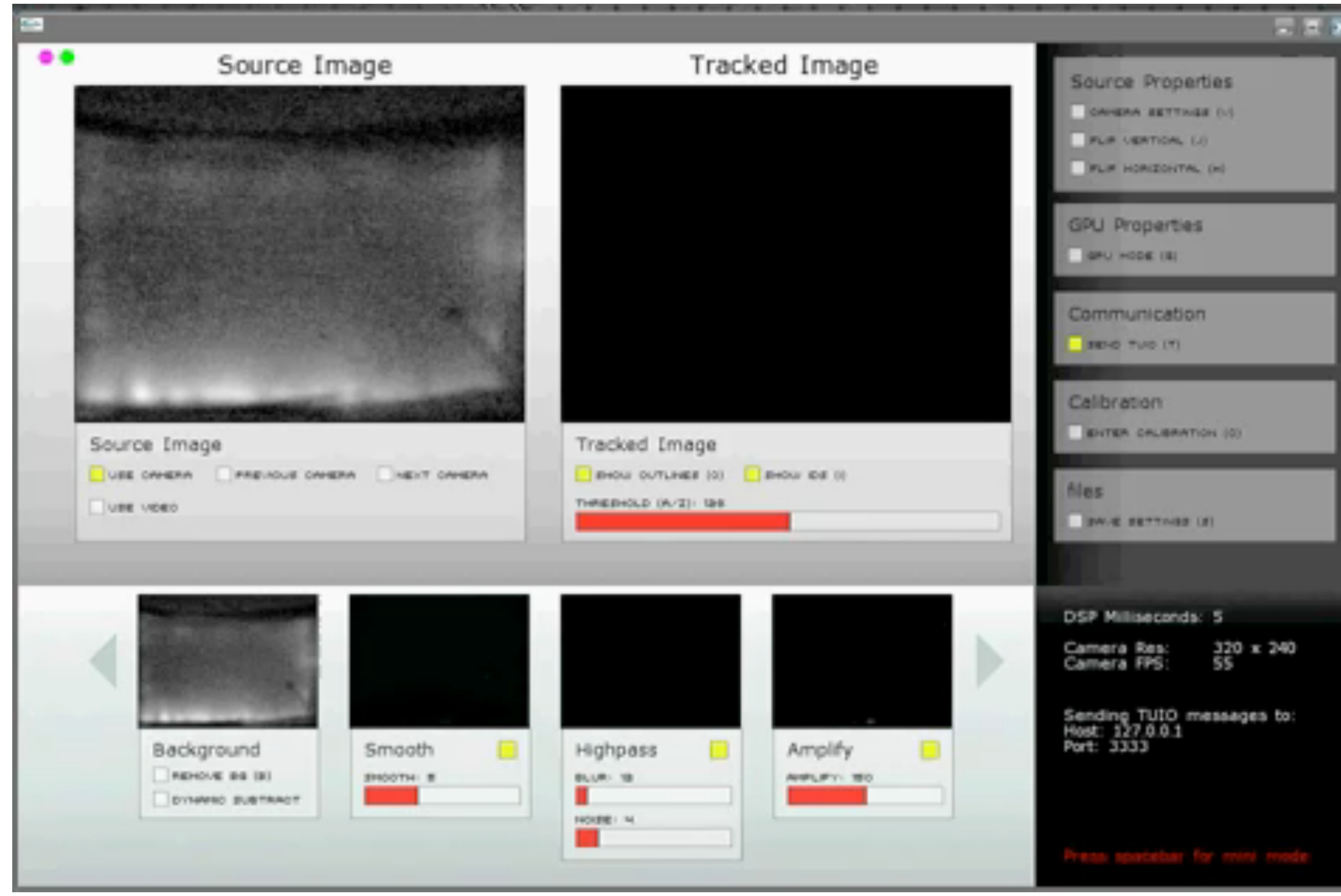
Reactable



Software for Interactive Surfaces

- Touchlib http://nuigroup.com/touchlib/
- Reactivision http://reactivision.sourceforge.net/
- the TUIO protocol http://www.tuio.org/

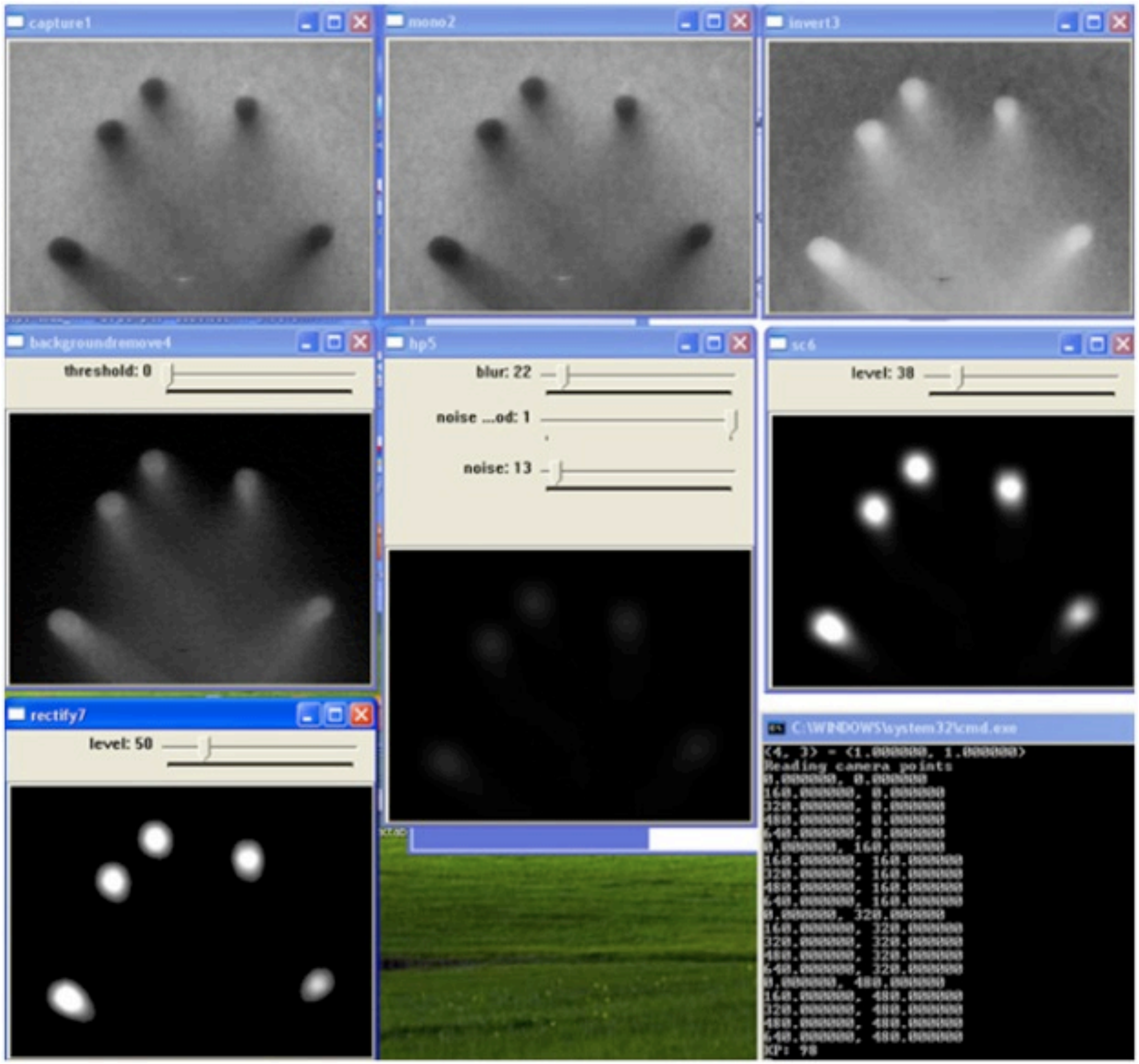
Touchlib and CCV



- The „classic“
- Touchlib is windows only
- CCV also Linux + OSX
- library for finger touch
- works w. diff. technologies
- also comes with a calibration app and several demos
- flame demos often seen in multi touch demo videos

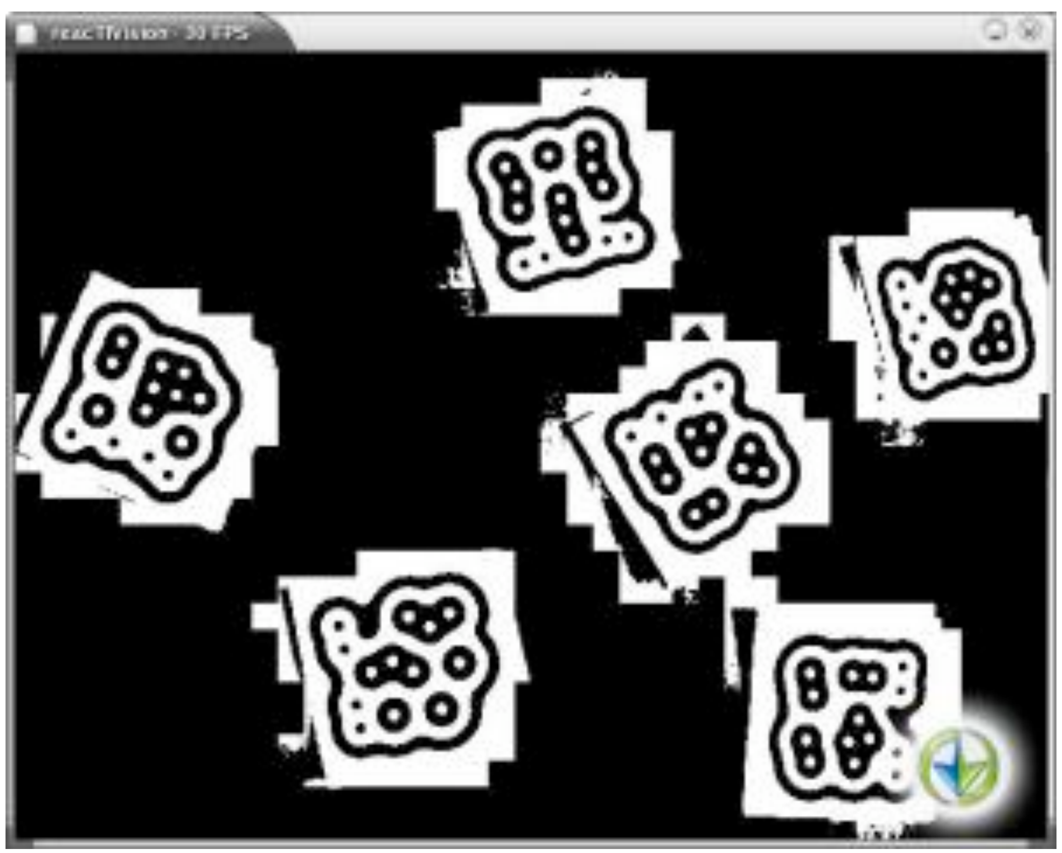
Multitouch DIY project for the weekend!

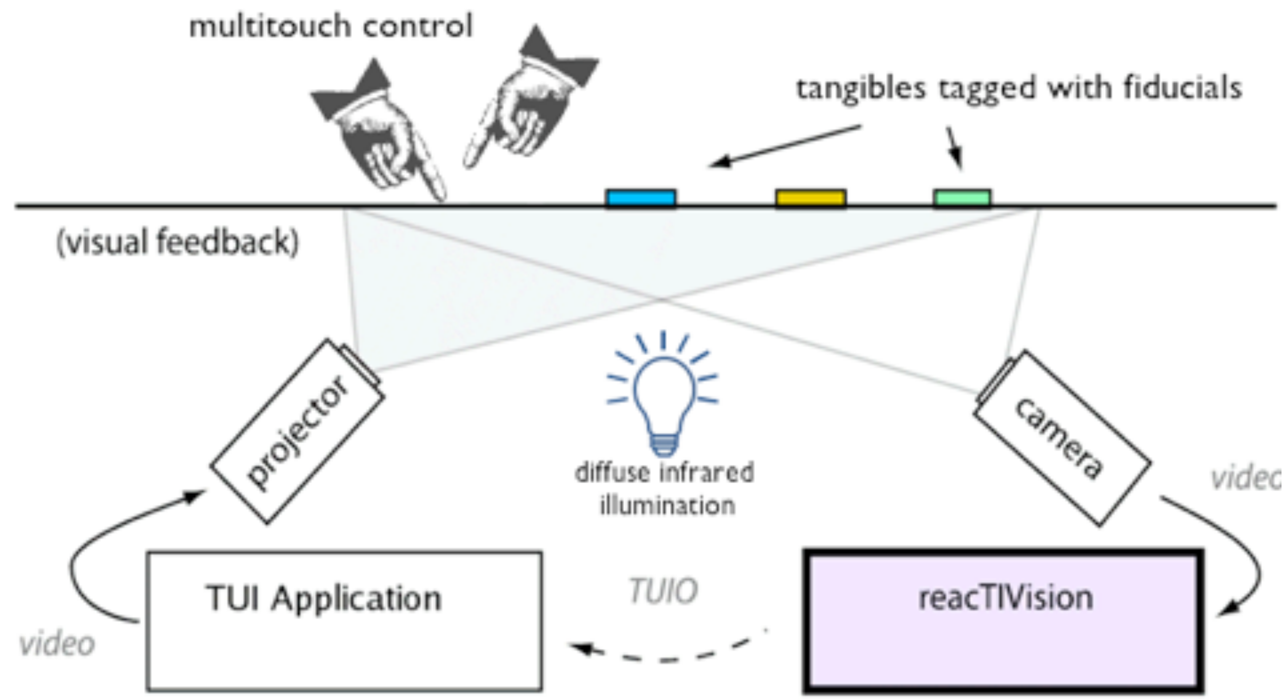
http://sethsandler.com/multitouch/mtmini/



Reactivision

- includes marker (aka fiducial) tracking
- uses the TUIO protocol
- originally built for the ReacTable musical instrument
- used in research for various purposes

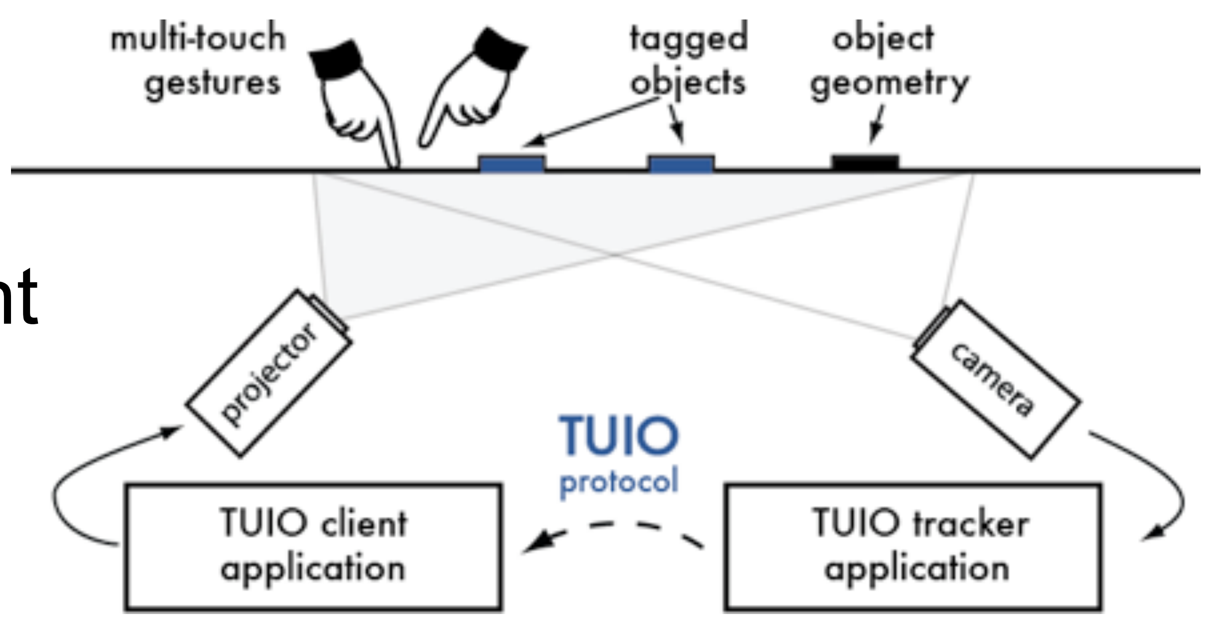




TUIO protocol

- Standardized protocol to send touch events
  - can describe fingers, shapes and visual markers
  - Sent over a network socket (often UDP packets on port 3333)
  - input can also be simulated
  - platform independent
- Various implementations (e.g., reactivision + CCV)
- Various demo clients available

- version 2.0 since April 2011
  - extensions to the message content
  - new capabilities
  - http://www.tuio.org/?tuio20



3D tracking technologies

- historic: magnetic 3D trackers
  - tons of side effects, calibration difficult, but: high frame rate!
- active marker tracking
  - need cables or batteries
  - robust tracking in exchange
- passive marker tracking
  - mainly sold for MoCap
- tracking without markers
  - popularized by Microsoft Kinect

3D tracking (passive markers)

- As an example: OptiTrack
- Uses retroreflective marker balls (why??)
- Needs several cameras for 3D reconstruction (how many??)
- Mainly sold for MoCap in 3D animation
- Small version also available in our lab!

http://www.youtube.com/watch?v=tBAvjU0ScuI

Kinect - depth camera (no markers)

- projects a pattern using an IR laser projector
- films this pattern and computes depth from it
- projector different from camera position! why?
- also contains RGB camera + microphones
- provides RGB image, depth map, skeleton

http://www.codeproject.com/Articles/317974/KinectDepthSmoothing

Kinect sensor data example

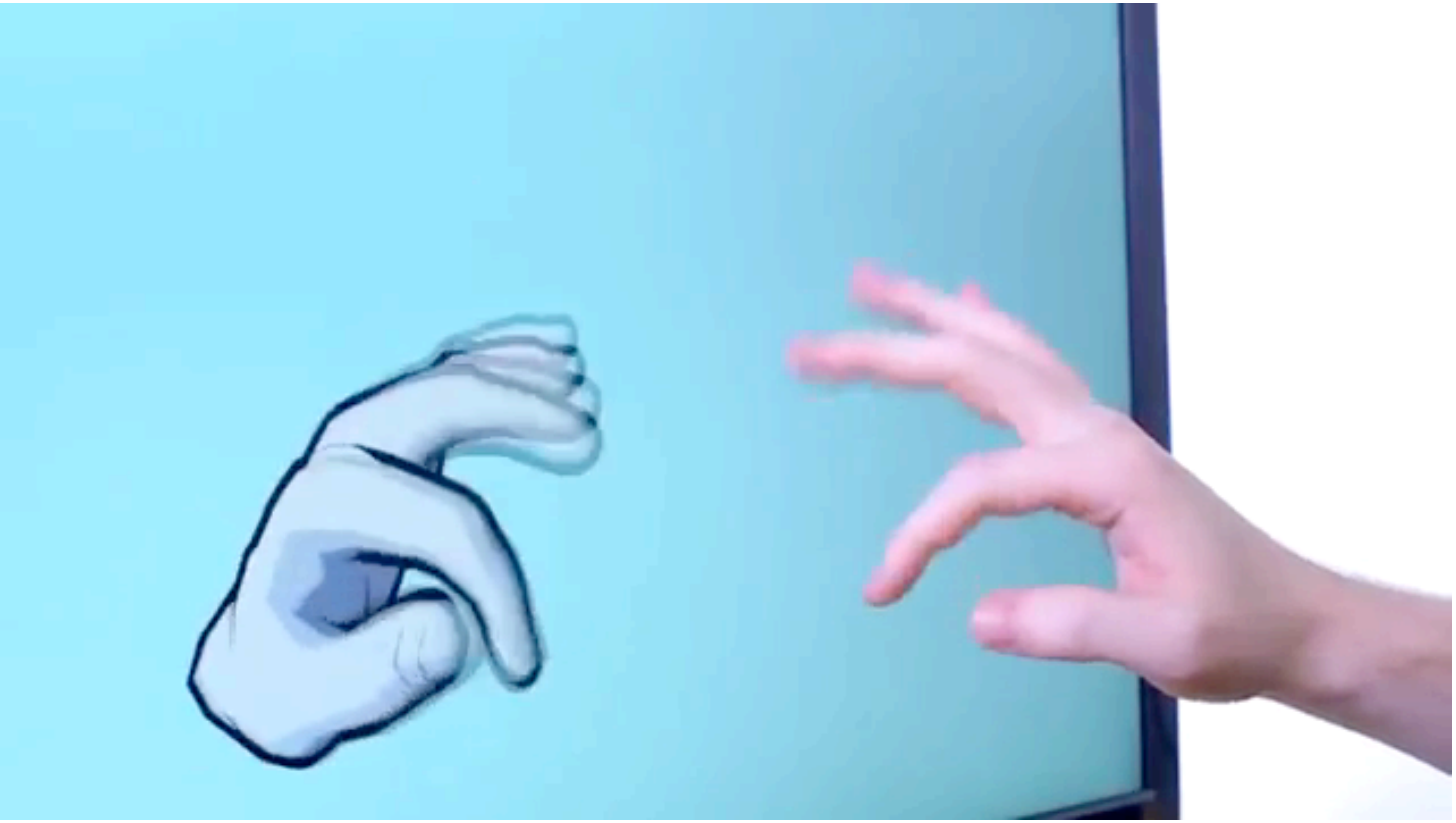
http://blogs.msdn.com/b/csharpfaq/archive/2012/02/06/start-coding-for-the-kinect.aspx

Kinect Fusion

http://msdn.microsoft.com/en-us/library/dn188670.aspx

LeapMotion

https://www.youtube.com/watch?v=gby6hGZb3ww#t=59
https://www.leapmotion.com



- contains 2 cameras and 3 IR (Laser?) LEDs
- exact working principle is still kept a secret

Take-away Message

- Interactive Surfaces still a developing field
- Robust & cheap sensing for large curved surfaces still an open problem

- Instrumented environments enabled by a multitude of different sensors

- commercialization only for mainstream markets (TV, gaming, Movies)
- „abuse“ of these cheap sensors in research

- fascinating playground for your thesis ;-)